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# COMMITTEE ON MILITARY NUTRITION RESEARCH

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## ACTIVITY REPORT 1986-1992

**92-18372**



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# REPORT DOCUMENTATION PAGE

Form Approved  
OMB No. 0704-0188

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1. AGENCY USE ONLY (Leave blank)		2. REPORT DATE 29 June 1992		3. REPORT TYPE AND DATES COVERED final: 30 Sept 86 - 31 March 92	
4. TITLE AND SUBTITLE Committee on Military Nutrition Research Activity Report 1986-1992				5. FUNDING NUMBERS DAMD17-86-G-6036	
6. AUTHOR(S) work of: Committee on Military Nutrition Research report prepared by: Bernadette M. Marriott and Robert Earl					
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Committee on Military Nutrition Research Food and Nutrition Board Institute of Medicine National Academy of Sciences 2101 Constitution Avenue Washington, D.C. 20418				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) Department of the Army U.S. Army Medical Research and Development Command Fort Detrick Frederick, MD 21702-5012				10. SPONSORING/MONITORING AGENCY REPORT NUMBER	
11. SUPPLEMENTARY NOTES This report is a summary of the activities of the Committee on Military Nutrition Research as supported by grant DAMD17-86-G-6030 reflecting the period of performance 30 Sept 86 - 30 Sept 91 plus a 6 month no cost extension through 31 Mar 92.					
12a. DISTRIBUTION/AVAILABILITY STATEMENT The report has been prepared in sufficient quantity to ensure distribution to sponsors, committee members, and to other relevant parties in accordance with Academy policy.				12b. DISTRIBUTION CODE	
13. ABSTRACT (Maximum 200 words)  The activities of the Food and Nutrition Board's Committee on Military Nutrition Research (CMNR) have been supported since 1986 by Grant No. DAMD17-86-G-6036 from the U.S. Army Medical Research and Development Command. This report presents a summary of these activities over the grant period from September 30, 1986, through September 31, 1991, including the period covered by a six-month no-cost extension to March 31, 1992. During this grant period the CMNR has met from three to six times each year in response to issues that are brought to the Committee through the Military Nutrition Division of the U.S. Army Institute of Environmental Medicine (USARIEM) at Natick, Massachusetts. The CMNR has submitted eight formal reports with recommendations to the Assistant Surgeon General since 1986 and has two major reports currently under preparation. These reports are summarized in the following activities report with synopses of additional topics for which reports were deferred pending completion of military research in progress. This activities report includes as appendixes the conclusions and recommendations from the eight reports and has been prepared in a fashion to allow rapid access to Committee recommendations on the topics covered over the time period.					
14. SUBJECT TERMS Activities, 5-years, nutrition for the soldier				15. NUMBER OF PAGES 145	
				16. PRICE CODE	
17. SECURITY CLASSIFICATION OF REPORT UNCLAS	18. SECURITY CLASSIFICATION OF THIS PAGE UNCLAS	19. SECURITY CLASSIFICATION OF ABSTRACT UNCLAS	20. LIMITATION OF ABSTRACT UL		

FRONT COVER

GRANT NO.: DAMD17-86-G-6036

TITLE: Continuing Support of Committee on Military Nutrition Research

PRINCIPAL INVESTIGATOR: Catherine E. Woteki

PI ADDRESS: Food and Nutrition Board, Institute of Medicine,

National Academy of Sciences, 2101 Constitution Avenue, Washington, D.C. 20418

REPORT DATE: 29 June 1992

TYPE OF REPORT: Scientific report for grant close-out

PREPARED FOR:

U.S. ARMY MEDICAL RESEARCH AND DEVELOPMENT COMMAND  
FORT DETRICK  
FREDERICK, MARYLAND 21702-5012

DISTRIBUTION STATEMENT: UNLIMITED

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# *Committee on Military Nutrition Research*

## *Activity Report*

**September 30, 1986,  
through  
March 31, 1992**

**Food and Nutrition Board  
INSTITUTE OF MEDICINE**

**Prepared by**

**Bernadette M. Marriott and Robert Earl**



**NATIONAL ACADEMY PRESS  
Washington, D.C. 1992**

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This report presents a summary of activities of the Committee on Military Nutrition Research (CMNR) from September 30, 1986, through March 31, 1992. Many of the activities mentioned here have resulted in reports that were previously published or submitted as letter reports to the sponsor and as such were reviewed by a group other than the authors according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. This activities summary has not been separately reviewed and represents an overview of all activities during the project period as designated.

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The activities of the Committee on Military Nutrition Research (CMNR) from September 30, 1986, through March 31, 1992, were supported by Grant no. DAMD17-86-G-6036 from the U.S. Army Medical Research and Development Command. The preparation of this report and partial funding for reports produced from January 7, 1992, through March 31, 1992, were supported by Grant No. DAMD17-92-J-2003 from the U.S. Army Medical Research and Development Command.

A limited supply of additional copies of this report are available from:

Food and Nutrition Board  
Institute of Medicine (FO-3050)  
2101 Constitution Avenue, NW  
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Printed in the United States of America

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## *Preface*

The diversity of the issues addressed by the Committee on Military Nutrition Research (CMNR) is well illustrated by the activities summarized in this report. This diversity has required the use of a broad range of expertise to respond to the issues brought to the CMNR. The range of scientific disciplines represented on the CMNR has been augmented as necessary through the use of workshops or special advisors to enable the CMNR to bring the degree and breadth of expertise necessary to properly respond to the subject under review. The committee has been pleased with and is very appreciative of the willing participation of the invited participants in these sessions and of their providing in many instances written papers, which have constituted a major part of the CMNR reports. Many of these workshops have included experts from within the military who have shared their research activities and information. They have been excellent representatives of the quality of research that the military has been conducting on many of these problems.

The military is to be commended for its approach to ensuring that the nutritional needs of its personnel are adequately met during the stress of military operations. There has also been interest and support for modifications of rations of military personnel consistent with the advice provided by the nutrition and public health leadership in the United States. The CMNR is cognizant of the desire to balance long-term health considerations with the demands of maintaining performance under the environmental extremes of military operations. The sodium content of operations rations discussed in this report illustrates this issue.

The ability of operational rations to help sustain military performance has been the subject of CMNR review since 1982. Field studies have shown

the adequacy of nutrient intake other than calories sufficient to maintain the weight of troops in the field. Complex interactions involving palatability of the ration components, convenience, fluid intake, socialization, and other physical and psychological stresses influence the consumption of operational rations. Further evaluation of these complex factors will undoubtedly continue to be of interest to the military and the CMNR in the future.

We are particularly grateful for the close working relationship with Colonel David Schnakenberg and Colonel Wayne Askew who have provided the liaison between the military and the Committee. They have greatly assisted the work of the Committee by bringing issues for consideration and helping to identify expertise familiar with these problems, particularly from within the armed forces.

As Committee Chair I express my deep appreciation to all of the Committee members who have given their time, dedication, and expertise to the careful analysis of the issues and to developing the conclusions and recommendations of the Committee. I also thank all participants in the many workshops who have greatly aided our activities and assured that the appropriate expertise has been available to the Committee. Finally I wish to express my appreciation to the staff of the Food and Nutrition Board assigned to this activity over the past 5 years.

In particular I acknowledge for myself and the entire committee the outstanding support presently provided to this activity by Bernadette Marriott, Ph.D., Senior Project Officer, Food and Nutrition Board, Institute of Medicine, and her assistant Valerie Breen. They have worked with extreme dedication to update and complete publication of several pending CMNR reports and to assure a timely response to the issues currently under consideration by the Committee. In writing this 5-year activities report the assistance of Robert Earl, Jo Harris-Wehling, and Leah Mazade is gratefully acknowledged.

Robert O. Nesheim, Ph.D.  
*Chair*

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## *Summary*

The activities of the Food and Nutrition Board's Committee on Military Nutrition Research (CMNR) have been supported since 1986 by Grant No. DAMD17-86-G-6036 from the U.S. Army Medical Research and Development Command. This report presents a summary of these activities over the grant period from September 30, 1986, through September 31, 1991, including the period covered by a six-month no-cost extension to March 31, 1992. During this grant period the CMNR has met from three to six times each year in response to issues that are brought to the Committee through the Military Nutrition Division of the U.S. Army Institute of Environmental Medicine (USARIEM) at Natick, Massachusetts. The CMNR has submitted eight formal reports with recommendations to the Assistant Surgeon General since 1986 and has two major reports currently under preparation. These reports are summarized in the following activities report with synopses of additional topics for which reports were deferred pending completion of military research in progress. This activities report includes as appendixes the conclusions and recommendations from the eight reports and has been prepared in a fashion to allow rapid access to Committee recommendations on the topics covered over the time period.

# *Background and Introduction*

## **HISTORY OF THE COMMITTEE**

The Committee on Military Nutrition Research (CMNR, the Committee) was established in October 1982 in response to a request from the Assistant Surgeon General of the United States Army. It was first organized within the Food and Nutrition Board (FNB) of the National Research Council's Commission on Life Sciences and in 1988 moved with the FNB to its new administrative home in the Institute of Medicine.

The Committee's mission is to advise the U.S. Department of Defense on the need for and conduct of nutrition research and related issues. Specifically it is charged with identifying nutritional factors that could critically influence the physical and mental performance of military personnel under environmental extremes, with identifying deficiencies in the existing relevant data base, with recommending approaches for studying the relationship of diet to physical and mental performance, and with reviewing and advising on nutritional standards for military feeding systems.

Within this context the CMNR was asked to focus on nutrient requirements for performance during combat missions rather than requirements for military personnel in garrison, because the latter were judged not to differ significantly from those of the civilian population.

Although the Committee membership has changed periodically, the disciplines represented have consistently included human nutrition, nutritional biochemistry, performance physiology, food science, and psychology.

## COMMITTEE PROCEDURES

Meetings are of three types. *Full committee meetings* are scheduled at the request of the Army to review nutrition programs, food products, and specific research projects in various stages of development. At these meetings oral presentations by Army personnel are augmented by written background material on one or more specific items for the Committee on Military Nutrition Research to review. The CMNR subsequently meets in executive session to discuss the materials and write a report to the Army that includes a summary of findings and recommendations. These reports are in the form of letters with attached supporting materials or brief, bound reports. *Subcommittee meetings* are convened by the Committee Chair either to plan future work, write reports, or, at the request of the Army, provide on-site review of research projects where the expertise of the entire Committee membership is not required. Reports drafted by subcommittees of the CMNR are subject to the review and approval of the entire Committee membership prior to completion. *Workshop meetings* are planned when issues have been presented to the CMNR by the Army that require broader expertise than exists within the Committee, or for which the Committee would like additional information or opinions. A CMNR workshop includes presentations from Army and other experts in nutrition and related sciences on an issue relevant to military nutrition research. The invited speakers are chosen for their specific expertise in the topic areas of concern and are asked to provide in-depth reviews of their area of expertise as it directly applies to a series of questions drafted by the sponsor. Speakers subsequently submit written versions of their presentations. These workshops thus provide additional state-of-the-art scientific information for the Committee to consider in their evaluation of the issues at hand. At the conclusion of the presentations, the Committee meets in executive session to discuss the issues and prepare conclusions and recommendations to be included as part of a book-style workshop report for subsequent release to the sponsors and the public.

Subsequent to approval of the final draft of a report by the Committee, in accordance with National Research Council guidelines, each report is reviewed in confidence by a separate, anonymous scientific review group. The Committee reviews the anonymous comments of this review panel and incorporates their suggestions where appropriate. Staff then write a response to the reviewers with the final report draft and obtain final approval of the report from the review panel. Each Committee on Military Nutrition Research report is thus a thoughtfully developed presentation that incorporates the scientific opinion of the CMNR and the comments of anonymous National Research Council reviewers.



## ORGANIZATION OF THIS REPORT

This summary of the activities of the Committee on Military Nutrition Research (CMNR) reflects the period of performance from September 10, 1986, through September 30, 1991, and includes activities during a six-month no-cost extension of performance through March 30, 1992, as supported by Grant no. DAMD17-86-G-6036 from the U.S. Army Medical Research and Development Command to the Food and Nutrition Board for the CMNR program. This report has been organized in topical fashion because the Committee was requested on occasion to repeatedly participate in reviews of research projects or products during several stages of their development over the course of this grant period. Topics are organized in a quasi-chronological fashion within the overall report and activities are organized in chronological order within topics.

A full listing of all committee members and committee meetings during the grant period are included in the appendixes. At a number of meetings the CMNR was presented with oral and written reports of research projects in progress or products under development. In a number of instances the committee deferred a full review of these items until the project was complete. Summaries are provided in the body of the report of all activities in which the Committee were requested to participate from September 30, 1986, through March 31, 1992, regardless of whether a report with recommendations was developed. The Committee typically prepares three styles of reports that correspond with their project requests and meetings: letter reports, brief reports, and workshop reports. These reports reflect the type of project under review, the length of study, and the time frame required for report generation. In the appendixes full copies of each letter report are included in the order mentioned in the text. For the brief reports and workshop reports, which are longer bound volumes, only the Committee summary and recommendations have been included in the appendixes.

# *Calorie-Dense Rations*

## **COMMITTEE ACTIVITIES**

During the period October 1, 1986–September 30, 1987, the Committee met three times—once in Natick, Massachusetts, and twice in Washington, D.C. The Committee's major task for these three meetings was to assist the Department of Defense in evaluating a nutrition sustainment module (NSM)—a food package designed to provide between 60 percent and 70 percent of calories from fat. In February 1987, the committee held a workshop on calorie-dense diets at which invited speakers discussed effects on the physical and mental performance of soldiers who consumed NSMs in the field for intermittent periods of 3–5 days. The committee presented its evaluation and recommendations in a letter report to the Surgeon General of the Army as part of the *Military Nutrition Research Annual Report, October 1, 1986–September 30, 1987* (NRC, 1988). The Annual Report contains the Committee's report on the NSM and the background papers for the workshop. These papers were prepared by an eminent group of scientists with expertise in this area and provide more detailed information on some of the issues discussed in the committee's report. A copy of the full letter report that resulted from this workshop is included in Appendix C. A listing of the background papers is included at the end of this section.

## **SUMMARY AND CONCLUSIONS**

The U.S. Army Natick Research Development and Engineering Center (USANRDEC) was asked to develop a calorie-dense ration (60–70% of

calories from fat). The primary considerations in the development of the ration were that its calorie density approach  $7.1 \text{ kcal/cm}^3$ , which would allow the dismounted soldier to carry easily a 3- to 5-day supply of food meeting a 3,600 kcal/day requirement. This ultimate means of refueling the soldier in the twenty-first century was called the Nutrition Sustainment Module (NSM).

The major focus of the workshop was the potential metabolic and gastrointestinal factors and the short-term and long-range health effects of the ration on the young soldier, who would consume the ration for the anticipated period of 3-5 days, with a likelihood that such short-term consumption could be repeated several times over the course of weeks or months. The key issue that was addressed by all participants was the ability of a ration that provides over 60% of calories from fat to sustain physical performance of the soldier, without chronic fatigue, over a 3- to 5-day period while the soldier is engaged in stressful, physically demanding activity, such as may be experienced in combat. Furthermore, to what extent, if at all, would mental acuity be compromised on such a diet? In addition to these key issues, other areas of concern included the following: What is the optimum ratio of carbohydrate to lipid? Does the nature of the lipid influence cognitive or physical performance? Are the amounts of protein and carbohydrate adequate? Is there a definable and practical time frame for adaptation to a high-fat diet? And what is the impact of all these considerations on mental and physical performance of the soldier under actual military conditions?

There was, of course, full recognition that high-fat diets similar to the proposed ration have not been extensively studied in a manner analogous to the proposed use by the Army. Hence, the conclusions reached were based on informed judgment of the participants. There was unanimous agreement by the committee and consultants that significant long-term adverse health effects were highly unlikely to occur under the conditions of proposed use. However, there was also agreement that if the ration were used as the sole source of nourishment either intermittently or for prolonged periods measured in months (e.g., 6 months or more), there would be concern about disturbances in serum lipids, which could lead to cardiovascular disease, and about the association between high-fat diets and cancer.

The Committee concluded that there appeared to be no nutritional advantage for the short-term use of a high-fat diet by troops during combat operations. In fact, the Committee and consultants unanimously concurred that it may be disadvantageous to increase fat at the expense of carbohydrates. The only advantage seen for such a ration was the provision of a day's anticipated caloric needs in a logistically determined cube that was easily transportable. There is evidence that adequate carbohydrate is the

preferred metabolic fuel to support a high level of sustained physical performance and to replenish the muscle glycogen used during extended periods of physical activity. Failure to replenish muscle glycogen adequately will result in a reduction in physical performance capability during subsequent periods and in early fatigue. In addition, there is a potential for adverse gastrointestinal disturbances under repeated exposures and conditions in the field. The potential for debilitating attacks of "heartburn" (and the difficulty of distinguishing this condition from a heart attack) and for the development of acute pancreatitis in susceptible individuals in field situations are also negative factors in the consideration of the use of such a ration.

The Committee identified that a key factor in evaluating the feasibility of using a high-fat ration is the intensity and duration of the physical activity that troops will encounter during combat. The metabolic consequences during conditions of usual activity may be minimal, but the consequences could be disastrous under conditions requiring intense, prolonged physical activity and emotional stress. Troops that are severely depleted of muscle glycogen may also have reduced cognitive ability, owing to the chronic fatigue and possible reduction in blood glucose available to support central nervous system functioning.

The Committee on Military Nutrition Research unanimously recommended that this ration not be put into use without appropriate evaluation. It saw no valid nutritional or physiologic reason why a ration with 60% or more of calories from fat should be used; however, if logistical reasons dictate that a calorie-dense ration of this type is required to meet field logistical requirements, it is essential that such a ration be evaluated under both laboratory and field conditions that approximate the anticipated combat operations in terms of intensity and duration of physical activity, mental stress, etc.

The CMNR further recommended that such evaluation should include measurements of physical and cognitive performance of and symptoms in individuals receiving:

- a high-fat ration with intakes approximating the energy expenditure;
- a ration with a volume similar to that of the high-fat ration, but providing a total of 400 g of carbohydrate with caloric intake limited by space requirements; and
- a "meal ready-to-eat" ration at caloric intakes similar to those of the rations described above.

In all instances, it was suggested that the evaluation be done with physical activities that closely duplicate anticipated combat scenarios and be

carried out for a period of at least the 3-5 days of anticipated use, but preferably for a 10-day period with daily performance evaluations.

Careful measurement of the various ration components actually consumed was deemed essential in order to provide information about the intake of calories and other nutritional components (e.g., vitamins and trace elements) of the ration.

It was suggested that initial studies could be conducted under laboratory conditions with follow-up field studies as indicated by the laboratory results, and that laboratory evaluations include exposure to hot and cold environments, as well as to high (hypoxic) altitude.

\* \* \* \* \*

The seven background papers from the workshop contained in the *Military Nutrition Research Annual Report, October 1, 1986-September 30, 1987* (NRC, 1988) are:

- Long-Term Health Effects of the Calorie-Dense Ration, by C. Wayne Callaway;
- Intestinal Digestion and Absorption of Fats: Current Concepts, by James J. Cerda;
- Energy Production During Exercise, by Phillip C. Gollnick;
- Effect of a High-Fat Diet (Nutrition Sustainment Module) on Endurance Capacity During Exercise of Different Intensities, by John L. Ivy;
- Long-Term Health Effects of High-Fat Diets: Heart Disease, by Ernst J. Schaefer;
- Effects of a High-Fat Diet on Gastrointestinal Function, by Michael D. Sitrin; and,
- Differences Between Carbohydrate and Lipid as Energy Sources, by Peter T. Stein.

## *Ration, Lightweight-30 Days*

The special forces asked the Army to develop a ration to adequately support the nutritional needs of their groups for 30 continuous days of field operations. Another important characteristic of the ration was that it must be light weight in order to be carried by the soldier in addition to other necessary equipment. For these purposes it was necessary for the ration to occupy no more than 0.8 cubic feet and weigh not more than 30 pounds. A ration was developed—the Ration, Lightweight-30 Day (RLW)—and a field study was conducted to determine whether the health and the physical and cognitive performance of soldiers could be adequately maintained on this ration under the specified conditions. The Committee on Military Nutrition Research (CMNR) was presented with the results of a field trial at their meeting on December 17, 1987, in Natick, Massachusetts.

The day's ration weighs less than 1 lb and is composed of 50 to 70 g of protein, 175 to 200 g of carbohydrate, and about 100 g of fat, which constitutes 40 percent of total daily calories. The ration provides about 2,000 kcal. The meals include a main course, bread crisp, cereal bars, a beverage, and a dairy bar. Most of the fat is in the dairy product. The ration was tested on 18 special forces soldiers during field training exercises. The Meals, Ready-to-Eat (MRE) VI served as the control ration for another 18 special forces soldiers.

A battery of physical and psychological tests was given before, during, and after the field trial. All soldiers carried food diaries to record their daily intake. An activity monitor was used to measure the activity of both groups.

The average caloric intake was about 2,800 kcal for soldiers consuming MRE and 1950 kcal for those consuming the RLW-30. The MRE group lost about 2.2 percent of body weight, while the RLW-30 group lost 6.3 percent.

In the RLW-30 group, both fat and fat free mass were lost whereas no measurable lean body mass was lost in the MRE group. Both of their nutrient intakes were compared with the Military Recommended Dietary Allowances (MRDA). Soldiers consuming the RLW-30 diet had slightly decreased intakes of protein, carbohydrate, fat, total energy, and vitamin A as compared to the MRDA. Sodium and protein content were purposely kept low in the test ration to ease the water burden on the soldier. The serum triglyceride and cholesterol levels stayed relatively stable in both groups.

Data regarding muscle strength, endurance, and aerobic capacity were also presented. Isokinetic muscle strength was not severely affected by diet, but aerobic capacity decreased 10.2 percent for the MRE group and 14.8 percent for the RLW-30 group. It was noted that some decline in aerobic capacity during field exercises is normal, as soldiers do not run regularly in the field.

Mood symptoms and objective performance measures were presented also. The researchers were unable to document any differences in mood between the two groups. Learning ability of soldiers fed the RLW-30 appeared to decrease, as did self-initiation. The reaction time of this group of soldiers also became slower as the test progressed. The researchers concluded that these findings deserved additional investigation.

Selected aspects of cognitive performance of the soldiers consuming the RLW-30 did not appear to be adversely affected. However, cognitive performance was determined by computer tests and the use of computers for cognitive testing in the field is a methodology not yet fully evaluated for its relevance to military operations.

Medical evaluations of the soldiers revealed no significant differences. Soldiers on the RLW-30, however, reported more gastrointestinal symptoms, such as nausea and upset stomach.

The Committee concluded in executive session that a formal report on the RLW-30 was not needed at this time and would be deferred until additional data had been accumulated. They commented that use of the RLW-30 was appropriate for a short period, not to exceed 30 days. The ration supported physical and mental performance reasonably well in a low-stress temperate environment (approximately 20 to 45°F). The Committee suggested that more research be done to enhance the palatability of the ration and to evaluate the ration under more severe ranges of environmental and field conditions.

## *Nuclear, Biological, and Chemical (NBC) Nutrient Solution*

Background and an overview of a test of the nuclear, biological and chemical (NBC) nutrient solution was presented to the Committee on Military Nutrition Research (CMNR) at their meeting on December 17, 1987, in Natick, Massachusetts. Some members of the Committee had previously served on a special Food and Nutrition Board (FNB) committee that had made recommendations concerning the NBC solution. The information was presented to the Committee primarily to inform them about the progress in implementing and evaluating the recommendations of the FNB special committee.

The purpose of the test was to determine the effect of the NBC nutrient solution on physiological and psychological indices during sustained activity in the heat.

The results indicated that (1) the NBC solution as a hydrating beverage provided little advantage over water for the first 12 hours of fasting, except that soldiers drank more of the NBC solution; (2) the performance of military duties could be supported by drinking water alone; (3) mood improved and self-reporting of symptoms declined after 12 hours on the NBC solution; and (4) weight loss did occur (1.35% NBC, 1.98% water control) but both groups maintained adequate hydration.

The Committee on Military Nutrition Research (CMNR) met in executive session and discussed the progress on this project. They concluded that a full committee report was not warranted at this time and deferred making formal recommendations until more research could be conducted. In reviewing the data presented on the NBC solution, the Committee suggested that the results of the test would be more realistic if done in a MOPP-4 suit.<sup>1</sup>



**NOTE**

<sup>1</sup> MOPP is the acronym for military operational protective posture, and the numeral 4 indicates full protective gear, including mask and gloves. The suit is impervious to chemical agents and is designed to totally protect the soldier from contamination. Air is breathed through a special filter in the mask, and fluids are available only through special tube arrangements. No dissipation of body heat or moisture other than through exhaled air is possible.

## *Military Nutrition Research at the Pennington Biomedical Research Center*

Congress mandated in the 1988 Department of Defense appropriations bill that \$3.5 million be allocated over three years by the Army to fund research programs at Louisiana State University's Pennington Biomedical Research Center (PBRC). The PBRC offers opportunities for research on nutrition as it relates to cancer and other chronic diseases, behavior, brain development, and obesity, and to findings at the molecular level. Of particular interest to the Army are issues that affect the nutritional status of Army personnel and their dependents during peacetime because of the overall interactive effects of food, diet, and nutrition on military readiness and preparedness.

### **CMNR DISCUSSION AND REVIEW OF NUTRITION RESEARCH CONCEPTS FOR THE PENNINGTON BIOMEDICAL RESEARCH CENTER**

During the meeting of the Committee on February 4, 1988, a presentation was made by Army personnel on concepts relevant to the goals and objectives of military nutrition research. Two of the major military nutrition research interests relative to the proposed Pennington program were (1) to assess the nutritional adequacy of dietary intakes of military personnel, and (2) to develop and evaluate nutrition education and health promotion programs as a part of a program to promote health and military preparedness.

Additionally, the Committee was informed by a presentation on a conceptual strategy of integrating the activities of the U.S. Army Research

Institute of Environmental Medicine (USARIEM) and the Pennington Biomedical Research Center. The Committee subsequently concluded that the work performed at USARIEM focused on meeting direct operational needs, was important and distinct, and should continue and that the two research programs/entities should be able to work collaboratively while pursuing different missions. For example, USARIEM is the more appropriate entity to conduct studies involving military personnel in field operational and simulated combat exercises. Conversely, the Pennington Center was envisioned as providing nutrition laboratory support, specifically the biochemical assessment of nutritional status, food biochemistry, or stable isotope technologies. The potential scope of military nutrition research at the PBRC would also include nutritional health promotion, the combat ration research, development, and evaluation program, and an exploration of the role of diet in maintaining and enhancing mental performance. The committee reported its position on the importance of retaining the research program at USARIEM in a letter report (see Appendix D).

#### **REVIEW OF RESEARCH PROPOSALS FOR THE PENNINGTON BIOMEDICAL RESEARCH CENTER**

The Committee met at the Pennington Biomedical Research Center in Baton Rouge, Louisiana, on December 12-13, 1988, to review and evaluate proposals for research to be conducted at the PBRC that would be most relevant to the Army. Following the presentations of eight applicants, the Committee met in executive session to discuss the relevance and usefulness of the proposals.

Criteria used in the review included (1) the time frame of the proposed project, given the uncertainty of funds after 1992; (2) emphasis on health promotion as well as basic research; and (3) potential of providing information relevant to the goals of the Research Center and the needs of the Army. The Committee noted that its review of proposals would have benefited from a clear understanding of the research agenda within which the proposals were presented.

The Committee recommended funding the proposal on risk appraisal and dietary intervention strategies for cardiovascular health. The remainder of the requests did not adequately address the needs of the Army—that is, the research designs were not clear in their relevance to military personnel and their dependents. The Committee, therefore, made no recommendation regarding funding these proposals (see Appendix D).

## **REVIEW OF RESEARCH PROGRESS AT THE PENNINGTON BIOMEDICAL RESEARCH CENTER**

At the request of Colonel Eldon W. Askew, Ph.D., Chief, Military Nutrition Division, U.S. Army Research Institute of Environmental Medicine (USARIEM), the Committee on Military Nutrition Research (CMNR) met at the Pennington Biomedical Research Center in Baton Rouge, Louisiana, on September 19-20, 1991. The purpose of this meeting was to assist the Army in reviewing and evaluating the progress on work related to the U.S. Army grant to the Pennington Biomedical Research Center: "Effect of Food, Diet, and Nutrition on Military Readiness and Preparedness of Army Personnel and Dependents in a Peacetime Environment."

Several of the Committee members and the Committee Chair, Robert O. Nesheim, had participated in the earlier reviews of the PBRC programs and were particularly cognizant of changes in physical plant and research programs that had occurred.

Prior to the meeting the CMNR reviewed an information paper provided by Colonel Askew and the final report by the grant principal investigator, Dr. Donna H. Ryan. The agenda for the meeting was planned by Dr. Ryan to provide the opportunity for presentation of research results and tour of the facilities, as well as time for the CMNR to meet in executive session to discuss their findings and draft their report.

### **Findings**

The Committee remarked that the Pennington Biomedical Research Center was a very impressive facility having an excellent physical plant for laboratory and clinical research. The CMNR further commented on the considerable progress that had been achieved in staffing and development of research activities since their last visit on December 12, 1988. This has been made possible by financial support from the U.S. Army, the U.S. Department of Agriculture, and grants from the National Institutes of Health, and other sources. In addition, the state of Louisiana has provided ongoing support at a level of \$4.1 million. The Committee commented that the vision and leadership of the newly appointed director of the PBRC, Dr. George Bray, were clearly evident in the impressive accomplishments of the Pennington Center in such a short time period. The Committee found that there was effective management support and guidance for the development of activities related to this grant through the leadership of the principal investigator, Dr. Ryan.

## CONCLUSIONS AND RECOMMENDATIONS

The Committee on Military Nutrition Research reviewed the five projects supported by the grant and provided individual reviews of each area. These are detailed in the letter report (see Appendix E) that while submitted to the U.S. Army after the period of performance on this grant, is included here as a part of the active work of the Committee during the grant period.

Generally, the Committee was impressed with the quality of the research activities at the Pennington Biomedical Research Center given the constraints of essentially starting from a zero base in equipping the facilities, recruiting staff, and initiating research activities, and felt that the funds provided by the U.S. Army grant had been effectively deployed. The CMNR would encourage continued financial support by the U.S. Army of those activities which have been and can continue to be relevant to the military, namely the Clinical Research Laboratory and the stable isotope activity. Further, support of the area of nutrition and behavior should continue with attention to developing a project with greater focus and hence military relevance.

It was the understanding of the CMNR that the Fort Polk Heart Smart Project had been completed, and that future funding was not planned under this program. The CMNR concurred with this position and also suggested that a thorough review of the results of this study and delineation of desired objectives, including inclusion of methodology to evaluate long-term outcomes, be conducted prior to consideration of implementation.

The Committee described a number of limitations of the research progress on the menu modification project and concluded that this project, if continued, should be conducted in a military facility where the staff was more familiar with the military menu and procurement systems in order for a practical program to be developed.

## *Use of Carbohydrate-Electrolyte Solutions for Fluid Replacement*

Military personnel are often called upon to perform heavy physical activity during training or combat in very hot environments, under varying levels of humidity, and other extreme environments. Such exposure may result in extensive loss of electrolytes, often with adverse physiological consequences. Recognizing the importance of the relationships among consumption and expenditure of energy, intake and loss of electrolytes, and fluid requirements in different environments, the U.S. Army Research Institute for Environmental Medicine (USARIEM) asked the Food and Nutrition Board (FNB) to explore the question of the utility of using carbohydrate-electrolyte solutions in the Armed Forces. Responding to this request, the FNB Committee on Military Nutrition Research (CMNR) convened a workshop to review the current state of knowledge on fluid replacement and stress. This invitational workshop was held at the National Academy of Sciences in Washington, D.C., on February 16-17, 1989. A subcommittee of the CMNR had been briefed on the key issues and provided input in the development of the workshop agenda and invited speakers during the meeting of the full Committee on September 9, 1988.

The Committee's report, *Fluid Replacement and Heat Stress: Proceedings of a Workshop*, includes recommendations for future research and for the composition of carbohydrate-electrolyte solutions (IOM, 1991a). The report also includes the 15 papers presented at the workshop. Appendix F contains the Committee's complete summary of findings and recommendations from the workshop.

## FINDINGS

Workshop findings indicate that the physical demands and extreme environmental conditions that occur during military training and operations may lead to one of several adverse conditions (e.g., dehydration, electrolyte imbalance, glycogen depletion, diarrhea, and/or vomiting) that affect either or both the physical and cognitive performance of soldiers. Under such extreme conditions, particularly in hot and humid environments, current research in the areas of exercise physiology and management of diarrheal diseases in developing countries indicates that carbohydrate-electrolyte solutions play an important role in preventing fluid, electrolyte, and glycogen depletion, thereby maintaining a soldier's performance.

Water intake is the primary requirement to ensure adequate hydration during stress not associated with intense physical activity and during sedentary activity in extreme psychological and/or environmental stress. With normal fluid and food intake, carbohydrate and electrolyte balance may be restored from losses due to stress. In extreme environments, however, additional intake of fluid, carbohydrate, and electrolytes is necessary. The palatability of carbohydrate-electrolyte replacement solutions is also important to ensure adequate consumption and compliance by military personnel.

## AREAS FOR FUTURE RESEARCH

Workshop presentations provided a thorough overview of the current knowledge base on fluid replacement and stress. The contents of the papers will provide military research investigators with important guidance in the evaluation, development, and testing of carbohydrate-electrolyte solution products for military use. The Committee believes that more research is needed on energy, electrolyte, and fluid requirements in different environmental and operations situations by military personnel. The Committee listed nine specific research issues for further investigation.

## CONCLUSIONS AND RECOMMENDATIONS

From workshop presentations and subsequent discussion by the Committee in executive session, it concluded that, when used appropriately, carbohydrate-electrolyte beverages appear to have the potential not only to maintain but also to enhance performance and endurance in a variety of military situations, particularly those that require sustained moderate to

heavy activity for extended periods of time. The composition of such beverages must match the needs of the environment in which used and should have the flexibility to be used in a variety of ways to meet the specific needs and preferences of military personnel. The goal of using carbohydrate-electrolyte solutions in beverage preparations should be to maximize fluid intake, replace electrolyte losses, and provide a carbohydrate source for rapid replenishment of muscle and liver glycogen stores during and following physical activity.

The Committee recommended that the Surgeon General of the Army evaluate the use of carbohydrate-electrolyte fluid replacement products as an aid to maintaining proper hydration of military personnel during periods involving psychological and environmental stress and also assess the effectiveness of these products in maintaining or enhancing both physical and cognitive performance during training and field operations. The Committee further recommended specific carbohydrate and electrolyte content levels for solutions and criteria for investigating the need for specific electrolytes by military personnel.



## *Analysis of Optimal Sodium Intake for Soldiers in Various Environmental Conditions*

The committee was asked to review the policy of sodium intake for soldiers. Questions focused on (1) whether sodium intake guidelines applicable to the general population were appropriate for soldiers, (2) the adequate level of sodium intake necessary to facilitate water absorption from the intestine, and (3) the appropriateness of the practice of placing a discretionary salt packet (4 grams) in the operational ration, Meal, Ready-to-Eat (MRE). The Committee met at the National Academy of Sciences in Washington, D.C., on May 22-23, 1989, for discussion of these issues in the context of the most current, relevant scientific data.

The Committee concluded that insufficient data existed on the adaptation to and acceptability of low levels of sodium among soldiers. An experimental design was proposed whose objective was to (1) measure the physiological and thermoregulatory response to heat acclimation of soldiers at reduced dietary sodium intake, and (2) determine the effect of reduced dietary sodium in the physical and psychological performance of soldiers during heat acclimation.

At a subsequent meeting of the CMNR on December 8, 1989, the Committee again discussed sodium intake for the soldier as part of a review of recent national nutrition and health guidelines. The Committee on Military Nutrition Research noted that the National Research Council's Committee on Diet and Health recommended 6 g or less of salt intake per day for the general population. The Committee subsequently recommended (IOM, 1991c) that daily sodium intake be no less than 6 g and no more than 10 g for military personnel. The Committee further noted that exceptions justifying additional intake could occur for military personnel under conditions creating large salt losses, such as those associated with heavy physical work in hot environments, particularly when troops were not adapted to the hot environment (see Appendix G).

# *Evaluation of Military Nutrition Initiatives Within the Context of Recently Published National Nutrition and Health Guidelines*

Military nutrition initiatives are only one segment of national-level efforts to improve the health status of the U. S. citizenry. The Committee reviewed the significant, recently published nonmilitary reports dealing with nutrition and health in the context of their relevance to the nutritional policies and practices of the military. Specifically, during parts of two committee meetings—on December 8, 1989, and June 28–29, 1990—invited speakers presented overviews and recommendations from the following reports: (1) the report *Diet and Health, Implications for Reducing Chronic Disease Risk*, of the National Research Council's (NRC) Food and Nutrition Board (NRC, 1989); (2) the U.S. Department of Health and Human Service's *Surgeon General's Report on Nutrition and Health* (DHHS, 1988); and (3) the *Year 2000 Health Objectives of the Nation* (DHHS, 1990). The CMNR also heard presentations of the results of dietary surveys conducted at several military installations, and the proposed health and nutrition promotion program activities for Army personnel.

## **CONCLUSIONS AND RECOMMENDATIONS**

The Committee, in general, endorsed the nine dietary recommendations of the NRC Committee on Diet and Health as being applicable to the military with the exception of the recommended level of sodium intake—the daily level of 6 g or less was considered to be too low for military requirements, particularly since troops consuming higher levels of sodium may

suddenly be exposed to hot, humid environments without adequate time to adjust to the lower sodium content of the combat ration. The Committee provided specific comments concerning the implementation of the recommendations from the NRC *Diet and Health* report by the military in their report to the Assistant Surgeon General of the Army, *Military Nutrition Initiatives* (IOM, 1991c). These recommendations are summarized below:

- The goal for military personnel should be to reduce their total fat intake to 30 percent or less of total calories, to reduce saturated fatty acid intake to less than 10 percent of calories, and cholesterol intake to less than 300 mg/day. To accomplish this, there should be a program of continued education of military personnel and their families as to appropriate food choices and an evaluation of possible menu changes and/or portion sizes in the military food service program.
- To meet the recommended goal of an intake of 6 or more daily servings of a combination of breads, cereals, and legumes, consideration should be given to the expansion of the number of starch selections available at each meal. Concern was expressed that monetary ration allowances may constrain the ability to purchase and store an adequate quantity of fresh fruits and vegetables to provide the desired daily intake of 5 or more one-half cup servings. The Committee commented that frozen or canned fruits and vegetables are acceptable alternatives.
- As the proportion of energy derived from carbohydrate increases, the percent calories from protein will decline. The use of dietary carbohydrates for fuel during physical activity is consistent with the *Diet and Health* recommendation that protein intake be maintained at a moderate level, i.e., approximately 0.8 g/kg body weight and not to exceed 1.6 g/kg body weight.
- Total caloric intake should be adjusted to achieve and maintain military body weight and body composition.
- A nutrition education program should be established for military women that promotes an adequate dietary intake of calcium. Additionally, garrison feeding programs should provide a range of low-fat, calcium-rich foods.
- Recommendations in the Surgeon General's report and the Year 2000 Health Objectives were compatible, in general, with dietary policy of the military. The NRC *Diet and Health* recommendations regarding use of alcoholic beverages, dietary supplements, and optimal intake of fluoride were endorsed as being appropriate for the military.

The summary and recommendations from the brief report *Military Nutrition Initiatives* (IOM, 1991c) is provided in Appendix G. The full report

**includes copies of the briefing materials, presentation graphics, additional references, and excerpts from the minutes of the two meetings upon which the report is based.**

## *The Relationship of Soldier Body Composition to Physical Performance*

The relationship of body composition to performance of physical tasks is of major interest to the military. Not only is it important in the decisions of acceptance or rejection of recruits for military service, but it also has significant implications for the individual relating to retention and advancement while in the services. There are financial implications as well for the military services, due to the high cost of training replacements when individuals are discharged for failure to meet the established standards. The discharge of highly trained and experienced specialists has significant additional implications concerning unit readiness and performance.

In 1989, personnel from USARIEM raised the question with the CMNR of the relationship of body composition to physical performance. Of particular interest was the application of then current height-weight standards in recruitment and retention of military personnel to the performance of military tasks. Although the tasks of military personnel are increasingly diverse, the Army contends that all individuals need to maintain a certain level of physical fitness to preserve the combat readiness of the services in general. However, with the increasing diversity of military personnel in terms of gender, ethnicity, and age, there was a concern whether current standards were appropriate and were uniformly applied in recruitment and retention. The applicability of these standards to the mission requirements of the services was also questioned. The CMNR reviewed these issues and concluded that a workshop was needed to review the literature, provide additional information on military standards, provide the most current research findings from within the Army related to this issue, and hear interpretation of this issue from experts in related fields.

A small planning group was given the task of identifying the pertinent topics and the participants. This task force, comprised of Col. E. Wayne Askew and James A. Vogel of USARIEM and CMNR members Ed Horton, Richard Atkinson, Robert O. Nesheim, and FNB Staff Officer Susan Berkow, met at USARIEM on November 8, 1989, to plan the workshop. The task force developed seven questions to be addressed at the workshop:

1. Can or should physical performance assessments be used as criteria for establishing body composition standards in the services?
2. What is the relationship between body composition and performance?
3. The services currently use a maximal body fat standard. Should they also establish a minimum fat-free or lean body mass standard?
4. What factors should be considered in setting body composition standards?
5. Are performance and body composition standards redundant?
6. If performance criteria exist, are weight-fat standards needed?
7. How does one rationalize the different uses of body composition for performance, appearance, and health?

The workshop outline and participants were reviewed by the CMNR at its December 1989 meeting, and the workshop was held February 6-7, 1990, at the National Academy of Sciences in Washington, D.C.

The invited speakers were chosen for their specific expertise in the areas of body composition, performance, and obesity. They were asked to provide in-depth reviews of their area of expertise as it directly applied to the seven questions and to include their own recommendations on the issues. Speakers subsequently submitted written versions of their presentations. The Committee met after the workshop to discuss the issues raised and information provided. Committee members later reviewed the workshop presentations and drew on their own expertise and the scientific literature to develop their summary, conclusions, and recommendations. The summary and recommendations of the CMNR were later reviewed by an anonymous panel of peers according to National Research Council policy, and the CMNR was called upon to either refute or incorporate suitable changes to their report.

## CONCLUSIONS AND RECOMMENDATIONS

The conclusions and recommendations of the Committee on Military Nutrition Research will be submitted to the Assistant Surgeon General of the Army as part of the workshop report, *Body Composition and Physical*

*Performance, Applications for the Military Services* (IOM, 1992, in press) in July 1992.

These workshops are a part of the response the CMNR provides to the Assistant Surgeon General of the U.S. Army (U.S. Army Medical Research and Development Command, Frederick, Maryland) on issues that are brought to the Committee through the Military Nutrition Division of the U.S. Army Institute of Environmental Medicine (USARIEM) at Natick, Massachusetts.

The proceedings of this workshop will be published and disseminated to provide (a) a review of current knowledge on the relationship of body composition to physical performance, (b) a discussion of the application of this data base to accession and retention standards in the military services, and (c) an evaluation and recommendations for consideration by the military in relating body composition to physical performance. While the Committee on Military Nutrition Research recognizes that body composition, physical performance, and health status are closely linked to the amounts and types of foods ingested, a comprehensive discussion of nutrition as related to body composition and performance was deemed to be beyond the scope of this workshop. The CMNR thus has limited the report to a review of the scientific evidence relating physical performance to body weight and composition. It is anticipated that this information will aid the military in establishing body composition standards that are more appropriate to the task performance requirements of military personnel. In addition, the information from this workshop may be of more general interest to those civilians concerned with establishing physical testing criteria for jobs requiring minimum physical performance standards.

## *Review of the New Generation Survival Ration*

In conjunction with the U.S. Army Natick Research Development and Engineering Center's (USANRDEC) effort to update the old General Purpose Survival Packet, the Committee on Military Nutrition Research (CMNR) was asked by the military nutrition division of the U.S. Army Institute of Environmental Medicine (USARIEM) to review the proposed nutrition standards for the New Generation Survival Ration (NGSR) to determine if they were consistent with current scientific knowledge. During its meeting on June 28-29, 1990, at Natick, Massachusetts, the CMNR examined and tested the ration product under development and toured the USANRDEC and USARIEM facilities for development and testing of the NGSR. USANRDEC staff provided, as part of an overview presentation on the ration product, information on the critical nutrient specifications and expected conditions of storage and use. The product of this meeting is the Committee's report, *The New Generation Survival Ration* (IOM, 1991d).

There are several key criteria for the development of the New Generation Survival Ration. The new ration should provide adequate carbohydrate to prevent ketosis, be low in protein to conserve water needs, be shelf stable at high temperatures, require no preparation, and be sufficiently acceptable to positively influence morale. Since the survival ration is designed to be consumed for no more than five days, nutrient standards for standard military operational rations do not apply.

As a result of the Army's presentations, tours, and ration tasting, the Committee developed recommendations for further development and improvement of the NGSR. In brief, the Committee's recommendations cover:



- water conservation and the macronutrient profile of rations;
- complete macronutrient and micronutrient composition of rations;
- development of a compact, cereal-based high-energy bar;
- palatability and appropriateness of ration components to reduce waste and selective consumption;
- coordination between development and user agencies of the new ration;
- user comprehension of purpose and use of the new ration through revised instructional modules; and,
- use of past experience with survival rations to improve the new ration.

The full text and complete recommendations of *The New Generation Survival Ration* appear in Appendix H. The complete published report includes background material pertaining to the nutrient content and use of survival rations reviewed by the Committee.

## *Nutritional Adequacy of the Long Life Ration Packet*

The Army has two needs that are unaddressed by the existing military rations: (1) ration stock appropriate for Pre-Positioned War Reserve Stocks (PWRS)—that is, PWRS with reasonable shelf-life to minimize the burden of rotation and restocking prior to conflict; and (2) rations suitable during the initial ten days of conflict—that is, one that would be used in situations that hinder timely distribution of Meals, Ready-to-Eat (MRE) or other existing rations.

The U.S. Army Research Institute of Environmental Medicine (USARIEM) requested that the Food and Nutrition Board's Committee on Military Nutrition Research (CMNR) review and comment on the nutritional adequacy of the Long Life Ration Packet (LLRP) under development by the U.S. Army Natick Research Development and Engineering Center (USANRDEC). At its June 28, 1990, meeting in Natick, Massachusetts, the committee was briefed on the development of the LLRP and the two needs unaddressed by existing military rations. Subsequent to the meeting, the Committee produced a brief report, *The Long Life Ration Packet* (IOM, 1991b).

The proposed LLRP product evaluated by the Committee was shown to have reasonable troop acceptance, was inexpensive, and had a projected ten-year shelf life. Each LLRP contains a dehydrated entree, a cereal bar, a cookie component, a candy component, an instant beverage, and an accessory packet. An individual meal packet weighs less than one pound and would allow reduced long-term storage of MREs, resulting in fresher, higher-quality stocks of this ration.

The Committee made five recommendations on LLRP to the USANRDEC. In brief, the Committee's recommendations cover:

- maintaining the nutrient content and stability of the LLRP as compared to the MRE and the Military Recommended Dietary Allowances (MRDA);
- completion of comprehensive nutrient profiles on the five LLRP menu packets, comparison to MRDA, and development of a fortification strategy;
- demonstration of the possibility of achieving a 10-year shelf life for the LLRP while maintaining nutritional objectives;
- implementation of an ongoing quality assurance program for all military rations, including the LLRP; and,
- development of instructions for rehydration of LLRP components and the need for potable water.

The full text and complete recommendations of *The Long Life Ration Packet* appear in Appendix I. The complete published report contains the Committee's findings, recommendations, and background materials used in its deliberations.

## *Research Endeavors to Replace Coconut Oil in Reconstituted Milk Processing*

A status report on the topic of Reconstituted Milk Processing Enhancements was presented to the Committee on Military Nutrition Research at their June 28-29, 1990, meeting in Natick, Massachusetts, by staff of the Food Engineering Directorate, USARIEM. The project was begun in July 1989 in response to criticism of the use of coconut oil as a base in reconstituted milk products for military personnel on the Pacific and Mediterranean area bases. The overall objective of the project is the replacement of coconut fats with less saturated fats that are equally as acceptable as the current product in terms of product sensory characteristics. Additional considerations include stability of the final product and cost of the constituents involved in its production. The presentation focussed on the need for the product's development and an overview of the reported effects of fatty acids on cholesterol and lipoproteins. The USARIEM scientists reported that a contract had been let that ran from March 1990 through March 1991 to Kansas State University for determination of the optimum least saturated oil or blends for the new product. At the Food Engineering Directorate the research focus would be on evaluation of commercially available fat sources and determination of the storage stability of these various fats, followed by pilot plant production of filled milk using alternative fat sources. The research would culminate in a user study with evaluation of sensory and stability properties. The project was scheduled for completion on March 31, 1992, when procurement of new filled milk constituents would begin. The Food Engineering Directorate staff were currently involved in a six-month storage study of eight commercial fat sources using a balanced design and three temperature levels: 40, 80, and 100°F. It was noted by the speaker that the Army switched to 2% milk

approximately five years ago and there was no decrease in the volume of milk consumed, so it is expected that the new product, if palatable, will be consumed at the same rate.

### CONCLUSIONS AND RECOMMENDATIONS

The Committee had the opportunity to taste several test products during the meeting and commented on the evident variability in taste and texture on the tongue with the products presented to them. The CMNR questioned the need for a 3.25% milk, which is currently part of the procurement plans, and also queried whether the scientific team had identified if flavor or texture or both were the major acceptability issues. The CMNR deferred further discussion and recommendations until the project is completed.

## *The Alaska Cold Weather Trials of Military Operational Rations*

The Meal, Ready-to-Eat (MRE) was adopted as a replacement for the ration, Meal Combat Individual, for military service personnel in 1985. This ration serves to provide an individual meal when centralized feeding is impractical or not possible in a field setting. The initial MRE has been updated through a series of versions since 1985. The Committee has followed the progress of the field testing of the Meal, Ready-to-Eat in a cold environment through status reports on a series of trials across a number of years. The purpose of these studies has been to evaluate and compare the suitability of the MRE with and without the addition of supplemental ration packets. Concerns throughout have been acceptability of the ration, level of intake, and maintenance of body weight, composition, and normal blood chemistries during normal field operations. Status reports were presented to the Committee on Military Nutrition Research (CMNR) during their May 22-23, 1989, meeting in Washington, D.C., and the June 28-29, 1990, meeting in Natick, Massachusetts.

### **PROJECT STATUS REPORT 1989**

Results of a survey in 1988 of military personnel at all levels indicated that there was a need to develop a supplemental packet to enhance the acceptability of the MRE. The suitability of this high-calorie packet to enhance an older version of the MRE (MRE VI) and to provide a cold weather supplement for a newer version of the MRE (VIII) was the focus of a ten-day field trial in Alaska in March 1989 with troops from the 6th Infantry Division (Light). Troops from two Companies participated in the

project. Approximately half of the troops in one Company received 4 MRE VIs, and the other half received 3 or 4 MRE VIIIs each day. In the other Company, half of the troops were fed 3 MRE VIs plus a supplemental pack, and the other half received 3 MRE VIIIs with supplemental pack each day. The results of this study were presented to the CMNR for their information and commentary at the May 1989 meeting. The supplement pack enhanced the acceptability of the MRE VIII food items but not the MRE VI. However, the supplemental packet did appear to enhance overall nutrient intake, and resulted in maintenance of body weight loss within a reasonable, acceptable range among study participants. The CMNR did not see the need to develop a formal report regarding this project and concurred with the conclusion of the U.S. Army Research Institute of Environmental Medicine (USARIEM) scientific staff that the supplement packet should be procured to enhance nutrient intake derived from the older versions of the MRE (IV-VII).

#### PROJECT STATUS REPORT 1990

The results of an Alaska field trial comparison of the MRE VIII + Supplement Packet versus the Ration, Cold Weather (RCW) were presented to the CMNR at their meeting in Natick, Massachusetts, on June 28-29, 1990. The presentation focused on the experimental design, the data accumulated, and preliminary results. The purpose of the testing in addition to the specific rations, was the development of a feeding doctrine in cold weather. In particular, emphasis was placed on energy requirements in the cold. The height, weight, selected anthropometric measurements, and samples of blood and urine were collected from the participants before the beginning of the field test, during the eight-day test, and after it was completed. Participants wore activity monitors, and an estimation of energy expenditure was also made using the doubly labeled water method. Diet was monitored using a dietary log with a hedonic scale. Soldiers were instructed to save their trash, and the project staff compared trash with the dietary logs.

Initial data on hours of sleep, weight change, nutrient and energy intake, source of energy, hedonic ratings, water consumption, urine specific gravity, hematocrit, and hemoglobin were presented to the Committee. The findings demonstrated that:

- similar energy intakes were consumed from both rations;
- the energy intake was approximately 3,000 kcal/day;

- 3,000 kcal was inadequate to maintain body weight and meet the Military Recommended Dietary Allowance of 4,500 kcal;
- consumption of nutrients, with the exception of four micronutrients, was adequate;
- the MRE was more acceptable than the RCW; and,
- fluid intake was good.

Since both rations were similar the decisions for use could be based on logistical and tactical scenarios. Committee discussion and questions centered around the issue of 4,500 kcal as being a high daily recommended intake, specifics of methodology, and the time frame for completion of data analysis. It was noted that there was poor recovery on the activity monitors. Additionally it was commented on that the initial body weights may have been artificially high since they were obtained prior to deployment. This is in contrast with the final weights that were obtained in the field. The CMNR deferred making a report and recommendations pending completion of data analysis and a final report.



## *Military Recommended Dietary Allowances*

The U.S. Department of Defense (DOD) has utilized dietary recommendations with military personnel since 1919. During 1990 the Department of the Army began to discuss the need to revise the current version of the Military Recommended Dietary Allowances (MRDA). At the June 28-30, 1990, meeting of the Committee on Military Nutrition Research (CMNR), the U.S. Army Research Institute of Environmental Medicine (USARIEM) requested that the CMNR discuss the MRDA review and revision at its subsequent meeting. The impetus for initiating a discussion of the adequacy of the current MRDA and the need for revision resulted from the publication of the 10th edition of the Recommended Dietary Allowances (RDA; for the general, healthy American population) by the Food and Nutrition Board (FNB) in late 1989.

The November 27-28, 1990, CMNR meeting in Washington, D.C., was principally devoted to a discussion of the revision of the current MRDA. Colonel David D. Schnakenberg, Director, Army Systems Hazards, U.S. Army Medical Research and Development Command, provided a historical overview of military involvement with dietary recommendations. Early surveys of food consumption by soldiers resulted in establishment of the nutrient requirements for soldier training in 1919. These early requirements provided recommendations for consumption of protein, fat, and carbohydrate as a percentage of daily calories (12.5%, 25%, and 62.5%, respectively).

During the Second World War the focus on nutrient recommendations centered on optimal nutrition, not minimal requirements. Because of the emphasis on military nutrition, the FNB was established in 1940 under the auspices of the National Research Council, National Academy of Sciences, and began to prepare and publish RDAs for Americans. In 1947, the

Department of the Army implemented military regulation AR 40-250, providing specified minimum nutrient intake levels as the dietary standard for garrison and field rations. The MRDA under AR 40-250 (now AR 40-25; the first tri-service regulation) has been revised numerous times through 1985, with revisions resulting from expanding scientific evidence on diet and health and from information provided in revisions of the RDA. Current policy covers not only MRDA for macronutrients and micronutrients, but also clarifies the use of the MRDA in menu planning, dietary evaluation of populations, nutrition education and research, and food research and development.

Col. Schnackenberg's presentation was followed by additional presentations on the feasibility of attaining governmentally established dietary recommendations and the process of establishing RDAs.

The Committee then began an in-depth discussion with representatives from DOD agencies about their respective concerns related to the revision of the MRDA. Overall, their concerns focused on the need for balance and control of macronutrient intake (i.e., protein, fat, and carbohydrate) and reduction in total fat, cholesterol, and sodium. Additional issues focused on the promotion of lifelong health, the palatability and acceptability of garrison meals, and the preference of military personnel for eggs and high-protein diets.

With the recent experience during Operation Desert Shield in Saudi Arabia, there was considerable discussion over the MRDA for sodium and the need for increased daily intake of sodium and fluid in hot environments related to military performance. Several DOD agencies could not support a single value for sodium intake that would cover both normal intake and intake under extreme environments.

The CMNR concluded its meeting with a discussion around the discrepancies between the RDA and the MRDA and proposals to accept the 10th edition of the RDA as the MRDA. However, concerns over protein, sodium, fat, and cholesterol were of importance in promoting health and performance in military personnel. The CMNR deferred further discussion and the formulation of recommendations until receipt of the revised MRDA under preparation by the Army for comment.

## *Nutrient Requirements for Work in Hot Environments*

The Committee on Military Nutrition Research (CMNR) was asked by the Division of Military Nutrition, U.S. Army Institute of Environmental Medicine (USARIEM), to review current research pertaining to nutrient requirements for working in hot environments and to comment on how this information may be applied to military nutrient standards and military rations. The Committee was thus tasked with providing a thorough review of the literature in this area and interpreting these diverse data in terms of military applications. In addition to a focus on specific nutrient needs in hot climates, the Committee was asked to include consideration of factors that might change food intake patterns and therefore overall calories. The CMNR was presented with this problem as a direct result of the movement of the armed forces into Saudi Arabia in Operation Desert Shield in autumn 1990, and the Committee was thus organizing the workshop that resulted in this report while the American armed forces were actively engaged in Operation Desert Storm in early 1991. Although concern for adequate nutrition for the soldiers in Saudi Arabia prompted the initiation of this project, its scope was defined to include the nutrient needs of individuals who may be actively working in both hot-dry and hot-moist climates.

The principal questions that the CMNR was asked to address were:

1. What is the evidence that there are any significant changes in nutrient requirements for work in a hot environment?
2. If such evidence exists, do the current Military Recommended Dietary Allowances provide for these changes?

3. Do changes need to be made to military rations that may be used in hot environments to meet the nutrient requirements of soldiers with sustained activity in such climates?
4. Specifically, are the Meals, Ready-to-Eat (MREs) good hot weather rations? Should the fat content be lower? Should the carbohydrate content be higher?
5. What factors may influence food intake in hot environments?
6. Is there any scientific evidence that food preferences change in hot climates?
7. Are there special nutritional concerns in desert environments where the daily temperature may change dramatically?
8. Is there an increased need for specific vitamins or minerals in the heat?
9. Does working in a hot climate change an individual's absorptive or digestive capability?

To assist the CMNR in developing a response to these questions, a workshop was convened on April 11-12, 1991, that included presentations from individuals familiar with or having expertise in digestive physiology, energetics, macronutrients, vitamins, minerals, appetite, psychology, sociology, and taste and smell. The titles of the presented papers are listed below:

- Physiological Responses to Exercise in the Heat  
*Michael N. Sawka*
- Effect of Heat, Humidity, and Work Load on Water Requirements  
*Carl V. Gisolfi*
- Overview of the Effects of Working in the Heat on the Functioning of the Gastrointestinal Tract  
*Carl V. Gisolfi*
- Energetics and Climate with Emphasis on Heat: Historical Perspective  
*E. R. Buskirk*
- The Effect of Exercise and Heat on Mineral Metabolism and Requirements  
*Carl L. Keen*
- The Effect of Exercise and Heat on Vitamin Requirements  
*Priscilla M. Clarkson*
- A Reevaluation of Sodium Requirements for Work in the Heat
  - A. Introduction and Physiological Responses During Heat Acclimation on 4 or 8 Grams of NaCl per Day  
*Lawrence E. Armstrong*

**B. Recurrent Daily Exercise in the Heat: Effects of a Salt-Restricted Diet on Hormonal Responses**

*Ralph P. Francesconi*

**C. Subjective Reports of Heat Illness**

*Richard F. Johnson*

- **Personal Observations of Soldier Food Intake Practices During Operation Desert Storm**  
*Robert Moore*
- **Psychological Response to Military Operations in a Hot Environment**  
*John E. Leu*
- **Heat as a Factor in the Perception of Taste, Smell, and Oral Sensation**  
*Barry G. Green*
- **Effect of Heat on Appetite**  
*C. Peter Herman*
- **Situational Influences on Food Intake**  
*Edward S. Hirsch*

The invited speakers discussed their presentations with the Committee members at the workshop and submitted the content of their verbal presentations as written reports. The committee met in executive session after the workshop to discuss the issues raised and the information provided. The members of the committee have met several times since the workshop to review the workshop presentations and draw upon their expertise and the scientific literature to develop a summary, conclusions, and recommendations. The CMNR is currently in the process of completing this report for submission to the Assistant Surgeon General, U.S. Army Medical Research and Development Command. The completed report will also include the written papers by invited speakers and will be submitted in early fall 1992.

## *Project Review of the Nutritional Adequacy of the Ranger Training Class, November 1991*

At the request of the U.S. Army Research Institute of Environmental Medicine (USARIEM), the Food and Nutrition Board's Committee on Military Nutrition Research (CMNR) met in Washington, D.C., on February 5-7, 1992, to assist the Army in reviewing and evaluating the results of a research project conducted during the training program for the U.S. Army Ranger Class of November 1991. The CMNR was requested to review the results of the nutritional assessment study of the November Ranger class conducted by USARIEM, to answer specific questions, and to make recommendations regarding the nutritional health and well-being of Ranger trainees and the need for future research.

The three-day meeting culminated in the production of the brief report, *A Nutritional Assessment of U.S. Army Ranger Training Class 11/91* (IOM, 1992). On the first day, the CMNR met to review the Ranger assessment with five invited advisors to augment their expertise in the areas of energy metabolism, vitamin/mineral nutrition, immunology, protein metabolism, and direct evaluation of Ranger training data. On the second and third meeting days the Committee and their advisors met in executive session to discuss the previous day's presentations, to answer questions, and to develop recommendations.

The report covers the questions posed to the Committee by USARIEM, a summary of specific recommendations, response and discussion of USARIEM questions, and areas for future research. The Committee was asked five specific questions related to Ranger training.

1. Is the change in the nutritional status of Ranger trainees of sufficient magnitude to compromise their health during Ranger training?

2. Are the changes in nutritional status noted transitory and not cause for undue medical concern, or are they severe enough to cause concern for the long-term physical health of the individual (post-Ranger training)?
3. Are the immunological changes noted related to the plane of nutrition during Ranger training or to other (e.g., sleep deprivation) stressors?
4. Realizing that food restriction is an integral part of Ranger training, can the nutritional status (risk) be improved significantly by relatively minor changes in the plane of nutrition?
5. Should Ranger trainees be furnished with multivitamin supplements?

To answer the questions above, the Committee considered the Ranger assessment data and the material covered during presentations. The Committee summarized their responses to the five questions and other recommendations related to their charge in three categories: during Ranger training, short-term follow-up, and long-term follow-up.

#### *During Ranger Training*

- Establish a "food doctrine" to prevent excessive weight loss.
- Establish a maximum allowable body weight loss for Ranger training consistent with Army guidelines.
- Review protocols for assuring the health of trainees during the entire training program.
- Consider modifications to apparel worn by Ranger trainees that will reduce dermal injuries and inflammation.
- Protocols need to be developed to document the occurrence, timing, severity, and etiology of clinical findings, such as overt infections, dermal injuries and inflammation, and problems related to climate, as well as prescriptions of all medication.
- Apply 1 of the 3 suggested modifications to the feeding program possible by immediately implementing the use of the Food Packet, Long Range Patrol (Improved) (LRP).
- Develop a post-training refeeding and preventive health education presentation with written materials for the guidance of training program participants.

#### *Short Term Follow-up*

- Expanded exit examination for all trainees.
- Physical examinations at 3, 6, 9, and 12 months in the first year post-training that include physical, clinical, and biochemical measurements.

- During the first 6 months, careful attention to the residual capacities of the Rangers, especially personal motivation, history of infection and illness, weight gain and body composition, ventricular and diaphragmatic muscle function, hydration of lean tissue, and thermoregulatory capabilities.

#### *Long Term Follow-up*

- Expanded yearly physical examinations if possible with a recorded history of major illnesses.
- Further prospective studies only if warranted.
- Conduct retrospective research study using existing data bases.

The Committee felt that there was an important question not posed by the USARIEM: What degree of stress, through such stressors as food deprivation, sleep deprivation, extremes of environment, and physical and mental performance tasks, under the watchful eyes of evaluators, is necessary to achieve the training objectives? The CMNR encourages the U.S. Army to systematically evaluate all aspects of the Ranger training program and its components through follow-up both immediately and several years post-training. This may provide additional insight into what aspects of the Ranger training program may be most beneficial to subsequent leadership abilities and performance in combat or during special operations.

The CMNR concluded that the questions raised by the Ranger nutritional assessment project were of great importance. Further studies and evaluation will offer both improved conduct of Ranger training and may be of significant importance for the clinical management of injured and critically ill patients in both the military and private sectors. The summary and recommendations from the report appear in Appendix J. The complete published document, *A Nutritional Assessment of U.S. Army Ranger Training Class 11/91*, contains background information and materials from all presentations made to the CMNR (IOM, 1992).



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## *Appendixes*

**APPENDIX A Meetings of The Committee on Military Nutrition Research  
September 30, 1986 – March 31, 1992<sup>1</sup>**

<u>Dates</u>	<u>Topics</u>	<u>Location</u>
October 15, 1986	Ration, Light Weight-30 Day	Camp Ethan Allen, Vermont
December 3, 1986	Nutrition Sustainment Module	Natick, Massachusetts
February 12-13, 1987	Workshop on Calorie-Dense Rations	Washington, D.C.
May 5, 1987	Calorie-Dense Rations	Washington, D.C.
December 17, 1987	Ration, Light Weight-30 Day and Nuclear, Biological, Chemical Nutrient Solution	Natick, Massachusetts
February 4, 1988	Research at the Pennington Biomedical Research Center	Washington, D.C.
September 9, 1988	Carbohydrate-Electrolyte Solutions	Natick, Massachusetts
December 12-13, 1988	Review of Research Proposals: Pennington	Baton Rouge, Louisiana
February 16-17, 1989	Workshop on Use of Carbohydrate-Electrolyte Solutions	Washington, D.C.
May 22-23, 1989	Review of Sodium Intake in Soldiers and other topics	Washington, D.C.
November 8, 1989	Workshop Planning Meeting	Natick, Massachusetts
December 8, 1989	Army Nutrition Initiatives and National Nutrition and Health Goals	Washington, D.C.

February 6-7, 1990	Workshop on Body Composition and Physical Performance	Washington, D.C.
June 28-29, 1990	Operational Rations, Reconstituted Milk, Alaska Trials of the MRE VII + Supplement	Natick, Massachusetts
September 9-10, 1990	Report writing and Committee business	Washington, D.C.
November 27-28, 1990	Military Recommended Dietary Allowances	Washington, D.C.
April 11-12, 1991	Workshop on Nutrient Intake in Hot Environments	Washington, D.C.
September 19-20, 1991	Review of Research: Pennington Biomedical Research Center	Baton Rouge, Louisiana
February 5-7, 1992	Nutritional Assessment of Ranger Training	Washington, D.C.

<sup>1</sup> Listed are all full committee meetings, workshops, and planning meetings. Sub-committee meetings and working sessions are not included.

## *Appendix B*

### **COMMITTEE ON MILITARY NUTRITION RESEARCH (CMNR) MEMBERS<sup>1</sup>**

**September 30, 1986 through March 31, 1992**

**ROBERT O. NESHEIM, (Chairman), Monterey, California**

**RICHARD ATKINSON, Veterans Administration Medical Center, Hampton,  
Virginia**

**WILLIAM R. BEISEL, Department of Immunology and Infectious Diseases,  
Johns Hopkins University School of Hygiene and Public Health, Baltimore,  
Maryland**

**ANDRE BENSADOUN, Division of Nutrition Science, Cornell University,  
Ithaca, New York**

**E. R. BUSKIRK, Laboratory for Human Performance Research,  
Pennsylvania State University, University Park, Pennsylvania**

**C. O. CHICHESTER, Department of Food Science and Technology,  
University of Rhode Island, Kingston, Rhode Island**

**WILLIAM EVANS, United States Department of Agriculture, Human  
Nutrition Center on Aging, Tufts University, Boston Massachusetts**

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<sup>1</sup>Unless footnoted, affiliations listed correspond to initial committee membership period.

**ALLEN L. FORBES**, Office of Nutrition and Food Sciences, Center for Food Safety and Applied Nutrition, Food and Drug Administration, Washington, D.C.

**JOEL GRINKER**, Program in Human Nutrition, School of Public Health, University of Michigan, Ann Arbor, Michigan

**ARTHUR L. HECKER**, Medical Nutrition Research, Ross Laboratories, Inc., Columbus, Ohio

**EDWARD HORTON**, Department of Medicine, University of Vermont College of Medicine, Burlington, Vermont

**RICHARD JANSEN**, Department of Food Science and Human Nutrition, Colorado State University, Fort Collins, Colorado

**JANET C. KING**, Department of Nutritional Sciences, University of California, Berkeley, California

**JOHN E. KINSELLA<sup>2</sup>**, Institute of Food Science, Cornell University, Ithaca, New York

**GILBERT LEVEILLE**, Nabisco Brands Incorporated, East Hanover, New Jersey

**JOHN MILNER**, Department of Nutrition, Pennsylvania State University, University Park, Pennsylvania

**RICHARD C. MOHS**, Veterans Administration Medical Center, Bronx, New York

**JAMES G. PENLAND**, USDA Agriculture Research Service, Grand Forks Human Nutrition Research Center, Grand Forks, North Dakota

**JERRY M. RIVERS**, Cornell University, Ithaca, New York

**DANIEL RUDMAN**, Geriatric Medicine, Veterans Administration Medical Center, North Chicago, Illinois

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<sup>2</sup>Current affiliation: College of Agricultural and Environmental Sciences, University of California, Davis, California

***COMMITTEE MEMBERSHIP***

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**JOHN VANDERVEEN**, Division of Nutrition, Food and Drug Administration, Washington, D.C.

**ALLISON YATES**, College of Health and Human Sciences, University of Southern Mississippi, Hattiesburg, Mississippi

*Appendix C*

*Letter Report: Calorie-Dense  
Rations, September 1987*



## NATIONAL RESEARCH COUNCIL

## COMMISSION ON LIFE SCIENCES

2101 Constitution Avenue Washington D C 20418

EXECUTIVE DIRECTOR

September 30, 1987

Major General Philip Russell  
Commander  
U.S. Army Medical Research  
and Development Command  
Fort Detrick, MD 21701-5012

Dear General Russell:

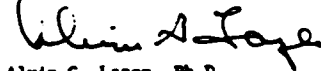
Pursuant to grant number DAMD17-86-G-6036 between the National Research Council and the Department of Defense, enclosed is the letter report on Calorie Dense Diets produced by the Food and Nutrition Board's Committee on Military Nutrition Research.

The Committee held a workshop on February 12 and 13, 1987, to assist its members in gathering the most current information and data pertaining to the topic. Several experts in fields of gastroenterology and lipid metabolism were invited to present papers, respond to the Committee's queries, and participate in the discussions.

In preparing the following report, the Committee has considered all of the available data and research findings pertaining to the proposed nutrition sustenance module, and has considered the potential impact of this ration on soldiers in the field, if used for short periods of time. The Committee's conclusions and recommendations are contained herein.

We hope that this report will be useful to you, and we look forward to working with you in the future.

Sincerely,



Alvin G. Lazen, Ph.D.  
Executive Director

Enclosure

cc: Col. David Schnakenberg  
Robert Nesheim

## Workshop on Calorie-Dense Rations

### INTRODUCTION

The U.S. Army Natick Research Development and Engineering Center (USANRDEC) has been asked to develop a calorie-dense ration (60-70% of calories from fat). The primary considerations in the development of the ration are that its calorie density approach  $7.1 \text{ kcal/cm}^3$ , which would allow the dismounted soldier to carry easily a 3- to 5-day supply of food meeting a 3,600 kcal/day requirement. This ultimate means of refueling the soldier in the twenty-first century is called the Nutrition Sustainment Module (NSM). (The composites of the ration and the logistical considerations in its development are described in detail in the background section beginning on p. 6.)

The Committee on Military Nutrition Research of the National Research Council's Food and Nutrition Board was asked by the Nutrition Research Division of the U.S. Army Research Institute of Environmental Medicine (USARIEM) and USANRDEC to assist them in evaluating the ability of the soldier to maintain adequate physical and cognitive performance when consuming this proposed ration. The committee along with seven invited consultants, several members of USANRDEC, and the Nutrition Research Division of USARIEM held a workshop on February 12 and 13, 1987, at the National Academy of Sciences (NAS) to review current knowledge of the effects of this type of ration on the performance capability of the soldier. The major focus of the workshop was the potential metabolic and gastrointestinal factors and the short-term and long-range health effects of the ration on the young soldier, who will consume the ration for the anticipated period of 3-5 days, with a likelihood that such short-term consumption could be repeated several times over the course of weeks or months. The key issue that was addressed by all participants was the ability of a ration that provides over 60% of calories from fat to sustain physical performance of the soldier, without chronic fatigue, over a 3- to 5-day period while the soldier is engaged in stressful, physically demanding activity, such as may be experienced in combat. Furthermore, to what extent, if at all, would mental acuity be compromised on such a diet? In addition to these key issues, other areas of concern included the following: What is the optimum ratio of carbohydrate to lipid? Does the nature of the lipid influence cognitive or physical performance? Are the amounts of protein and carbohydrate adequate? Is there a definable and practical time frame

for adaptation to a high-fat diet? And what is the impact of all these considerations on mental and physical performance of the soldier under actual military conditions?

There was, of course, full recognition that high-fat diets similar to the proposed ration have not been extensively studied in a manner analogous to the proposed use by the Army. Hence, the conclusions reached are based on informed judgment of the participants. There was unanimous agreement by the committee and consultants that significant long-term adverse health effects were highly unlikely to occur under the conditions of proposed use. However, there was also agreement that if the ration were used as the sole source of nourishment either intermittently or for prolonged periods measured in months (e.g., 6 months or more), there would be concern about disturbances in serum lipids, which could lead to cardiovascular disease, and about the association between high-fat diets and cancer.

## **BACKGROUND**

In anticipation of the need for a ration suitable for soldiers who will be involved in mobile battlefield situations, largely on foot and removed from traditional points of resupply, the Army has begun the development of a calorically dense, conveniently configured ration that could be eaten as is, without any additional preparation.

This ration was designed to contain the highest possible number of calories in a compact unit of about 0.454 kg (1 lb). The caloric density would approach 7.1 kcal/cm<sup>3</sup>. This ration density would permit the dismounted soldier to carry a 3- to 5-day supply of food, providing approximately 3,600 kcal/day, in addition to combat equipment. It appears from preliminary work conducted at USANRDEC that it is feasible to develop a ration of approximately this caloric density using a variety of innovative food engineering techniques. For example, reduction in the volume occupied by the ration is accomplished through such techniques as dehydration, compression, and extrusion. To achieve the desired caloric density, more than 60% of the calories in the proposed ration would be supplied by fat. This is accomplished in part by fat infusion. In general, the food bar is a carefully designed product with no wasted ingredients. For example, ascorbic acid serves both as a source of vitamin C and as an antioxidant; lecithin serves as a source of choline and serves as a surfactant and emulsifier, etc. In addition to providing an adequate amount of protein,

the NSM is a suitable carrier for all required water-soluble and fat-soluble vitamins and is fortified with minerals and trace elements. Furthermore, the ration is expected to contain only GRAS or other approved ingredients and is in conformance with Food and Drug Administration food regulations. The objective of the NSM is that it be nutritionally optimized to maintain physical and cognitive performance and that it be adequately acceptable and palatable to ensure consumption.

Listed below is a summary of the consultants' presentations and the consultants' and committee's discussions.

#### **I. METABOLIC ISSUES:**

The ability of a high-fat ration to support metabolically an adequate level of physical performance is linked to the intensity and duration of the physical activity. It is also linked to the fitness of the soldier and to his diet. It is clear from the experience of the consultants and from the literature on exercise physiology that adequate muscle glycogen is of paramount importance for the provision of energy during intense, prolonged exercise, particularly at an exercise intensity in the range of 60-75%  $\dot{V}O_{2\text{max}}$  (maximal oxygen consumption). Initial low concentrations of muscle glycogen result in shorter worktime to fatigue. The rate and extent of resynthesis of muscle glycogen depends to a large extent on the nutrient composition and quantity of food eaten during the recovery period. The amount of glycogen resynthesized is greater with a high-carbohydrate diet than with either a high-fat and high-protein diet or the usual mixed diet. At low to moderate exercise intensities, fatty acids are the primary source of energy used by muscle; however, carbohydrate also contributes substantially to energy production at these exercise intensities.

The following conclusions were reached by the committee and the workshop participants:

- a. Carbohydrate is the preferred metabolic fuel for physical performance, particularly at exercise intensities in excess of 45% of maximum aerobic power. People can adapt to use larger amounts of fatty acids as muscle fuel over a period of several days, but it has

not been substantiated that performance is not hindered by the ketosis and associated adverse symptoms that develop with an increase in fat use by those who perform hard exercise. It does not appear feasible to depend on the physiologic adaptation of soldiers to such a ration before they are thrust into combat, because such a diet is unlikely to be made available under garrison conditions or other preoperational living conditions.

- b. The depletion of muscle glycogen stores depends on the intensity and duration of physical activity. Subsequent intake of carbohydrate is necessary to restore muscle glycogen and to maintain physical performance. The workshop participants suggested that a ration to be used for the purposes described should provide a minimum of 400 g of carbohydrate per day to permit a reasonable rate of synthesis of muscle glycogen to help prevent chronic fatigue. The source of carbohydrate does not appear to be critical. A mixture of simple and complex carbohydrates would be most palatable. In the absence of the opportunity to rebuild muscle glycogen stores following extended physical activity, the ability to sustain intense physical activity will decline and acute or chronic fatigue can result.
- c. Studies show that highly trained athletes performing at approximately 70% of  $\text{VO}_2\text{max}$  until exhaustion rebuild muscle glycogen rapidly and are able to sustain performance significantly longer on subsequent days of highly intensive exercise when consuming a diet that provides 70% of calories from carbohydrate than when consuming diets that provide only 40-45% of calories from carbohydrate. While soldiers are not likely to sustain intense physical activity for several hours, it is possible that they will perform extended periods of more moderate activity repeated for several days, which would produce similar effects as muscle glycogen is gradually depleted.
- d. If the cubic capacity to carry rations is paramount, consideration should be given to providing a basic ration with at least 400 g of carbohydrate providing 40-45% of calories to aid in rebuilding muscle glycogen content, even if the total calories provided by the ration have to be reduced and are inadequate to maintain calorie balance. Most soldiers, except very lean individuals, would have more than adequate stores of body fat to sustain sufficient performance for the 3-5 days that the ration would be used.

e. To provide for additional carbohydrate, the protein content could be limited to 50 g/day. This amount should be adequate to sustain the soldier in the field for 3-5 days and possibly up to 30 days, even though it would not likely support nitrogen balance throughout the period. No reduction in aerobic power would be expected, because of the small negative nitrogen balance.

## II. GASTROINTESTINAL ISSUES:

Normal, healthy individuals are able to digest and efficiently absorb fat. No major gastrointestinal malabsorption problems would be expected under normal conditions. However, the workshop participants concluded that several key factors should be considered relative to the anticipated use of a high-fat ration:

- a. It is possible that the sudden introduction of a ration providing 60% or more of calories from fat could trigger the development of acute pancreatitis, particularly in a percentage of individuals with serum triglycerides in excess of 400 mg/dl. If a ration such as the one considered here is put to use, it may be necessary for personnel likely to be involved in combat to be screened on induction and periodically thereafter (perhaps every 5 years) for hypertriglyceridemia to minimize the risk of acute pancreatitis in the field. If the ration is to be consumed for periods of months, all potential users should be screened for total plasma cholesterol and HDL cholesterol.
- b. Troops suddenly transferred to tropical regions or unsanitary areas with rapid changes in water supply would likely be at high risk for the development of enteric infection or diarrhea, which could be aggravated by the high-fat ration.
- c. Since high-fat diets are known to lower esophageal sphincter pressure and to delay gastric emptying, there may be an increased incidence of "heartburn" due to reflux esophagitis, which can be debilitating in some people. Initial field diagnosis to determine whether it is "heartburn" or a heart attack can be difficult.
- d. It would be important to evaluate whether or not the following operational circumstances may preclude the use of a high-fat ration:

- (1) High-altitude exposure or other conditions resulting in hypoxia.
- (2) Hypohydration, possibly aggravated by the unpalatability of drinking halogenated treated water in the field.
- (3) Extreme heat or cold exposure.
- (4) Intense exercise.
- (5) Prophylactic treatment prior to enteric disease exposure.

(Various combinations of these circumstances may well take place under operational conditions.)

- e. Sufficient information is not available to provide a rationale for choosing which of the various types of fats and fatty acids (e.g., chain length, degree of unsaturation) should be incorporated in the ration. The choice will also be influenced by technologic constraints (e.g., the use of polyunsaturated fatty acids that liquefy at low temperatures) and the overall stability of the ration.

### III. LONG-TERM HEALTH ISSUES:

The projected use of the proposed calorie-dense ration is for a period of 3-5 days, possibly repeated several times over several weeks or months. There is extensive experience with populations consuming diets with 40-45% of calories from fat over extended periods. The effects of consuming a diet with 60% of calories from fat in the proposed manner have not been extensively evaluated. However, the workshop participants and the committee reached several conclusions about the potential short- and long-term health effects of the proposed ration:

- a. The most significant potential short-term health effect identified by the consultants and the committee was the possible precipitation of acute pancreatitis in hypertriglyceridemic individuals. It was concluded that individuals with fasting plasma triglyceride concentrations of 400 mg/dl or more should not consume such a ration. The identification of such persons would likely require screening military personnel at induction and periodically thereafter (possibly at 5-year intervals) for hypertriglyceridemia. If the ration

were to be used for a period of several weeks or even months, screening for total plasma cholesterol and HDL cholesterol should also be considered.

- b. Significant long-term health effects would be unlikely to occur under the conditions of proposed use. However, if this type of ration were to be used as the only source of nourishment for prolonged periods (several months), its long-term health effects would be of greater concern and should be studied.
- c. There is limited evidence that persons consuming high fat diets prior to major surgery may be more prone to complications such as sepsis as a side effect of surgery. There is some evidence, although not conclusive or substantiated by multiple investigators, that patients with high fat intakes parenterally, prior to major surgery, do not withstand surgery very well compared with patients on lower or no fat intakes (Müller et al., 1986; Jarstrand et al., 1978; Nordenstrom et al., 1979). The fat intakes in the Müller paper were comparable to the fat intakes under consideration for the calorie-dense rations. This has potential significance for severely wounded soldiers who have been consuming a high-fat ration for an extended period prior to injuries that require surgery.

#### OVERALL CONCLUSION

There appears to be no nutritional advantage for the short-term use of a high-fat diet by troops during combat operations. In fact, the committee and consultants unanimously concurred that it may be disadvantageous to increase fat at the expense of carbohydrates. The only advantage to such a ration is the provision of a day's anticipated caloric needs in a logistically determined cube that is easily transportable. There is evidence that adequate carbohydrate is the preferred metabolic fuel to support a high level of sustained physical performance and to replenish the muscle glycogen used during extended periods of physical activity. Failure to replenish muscle glycogen adequately will result in a reduction in physical performance capability during subsequent periods and in early fatigue. In addition, there is a potential for adverse gastrointestinal disturbances under repeated exposures and conditions in the field. The potential for debilitating attacks of "heartburn" (and the difficulty of distinguishing this condition from a heart attack) and for the development of acute pancreatitis in



susceptible individuals in field situations are also negative factors in the consideration of the use of such a ration.

A key factor in evaluating the feasibility of using a high-fat ration is the intensity and duration of the physical activity that troops will encounter during combat. The metabolic consequences during conditions of usual activity may be minimal, but the consequences could be disastrous under conditions requiring intense, prolonged physical activity and emotional stress. Troops that are severely depleted of muscle glycogen may also have reduced cognitive ability, owing to the chronic fatigue and possible reduction in blood glucose available to support central nervous system functioning.

### **RECOMMENDATIONS**

The Committee on Military Nutrition Research unanimously recommends that this ration not be put into use without appropriate evaluation, for the reasons described in this document. It sees no valid nutritional or physiologic reason why a ration with 60% or more of calories from fat should be used; however, if logistical reasons dictate that a calorie-dense ration of this type is required to meet field logistical requirements, it is essential that such a ration be evaluated under both laboratory and field conditions that approximate the anticipated combat operations in terms of intensity and duration of physical activity, mental stress, etc.

Such evaluation should include measurements of physical and cognitive performance of and symptoms in individuals receiving:

- a. a high-fat ration with intakes approximating the energy expenditure;
- b. a ration with a volume similar to that of high-fat ration, but providing a total of 400 g of carbohydrate with caloric intake limited by space requirements; and
- c. a "meal ready-to-eat" ration at caloric intakes similar to those of the rations described a and b above.

In all instances, the evaluation should be done with physical activities that closely duplicate anticipated combat scenarios and should be carried out for a period of at least the 3-5 days of anticipated use, but preferably for a 10-day period with daily performance evaluations.

Careful measurement of the various ration components actually consumed is essential in order to provide information about the intake of calories and other nutritional components (e.g., vitamins and trace elements) of the ration.

Initial studies could be conducted under laboratory conditions with followup field studies as indicated by the laboratory results. Laboratory evaluations should include exposure to hot and cold environments, as well as to high (hypoxic) altitude.

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*Appendix D*

*Letter Report: Plans for the  
Pennington Biomedical Research  
Center, June 1989*

INSTITUTE OF MEDICINE  
NATIONAL ACADEMY OF SCIENCES

2101 CONSTITUTION AVENUE WASHINGTON, D. C. 20418

FOOD AND NUTRITION BOARD

June 26, 1989

Major General Philip K. Russell  
Commander  
U.S. Army Medical Research  
and Development Command  
Fort Detrick, MD 21701-5012

Dear General Russell:

At the request of the Nutrition Research Division of the U.S. Army Research Institute of Environmental Medicine (USARIEM), the Food and Nutrition Board's (FNB) Committee on Military Nutrition (CMN) of the Institute of Medicine convened at Louisiana State University's (LSU) Pennington Biomedical Research Center at Baton Rouge, Louisiana, on December 12, 1988. The purpose of this meeting was to assist the Army in reviewing and evaluating proposals for research to be conducted at the Center in order to identify those that would provide the most useful data for program planning.

The Pennington Biomedical Research Center will offer opportunities for research on nutrition as it relates to cancer and other chronic diseases, behavior, brain development, and obesity, and to findings at the molecular level. Of particular interest to the Army are issues that affect the nutritional status of Army personnel and their dependents during peacetime because of the overall interactive effects of food, diet, and nutrition on military readiness and preparedness. For this reason, the House Authorization Committee has allocated \$3.5 million for the Army to fund nutrition research programs at LSU Pennington Biomedical Research Center (DOD Appropriations Bill, 1988). The Center is at a stage where development of a research agenda that matches LSU's programs with the needs of the Army is appropriate. The research will constitute only part of the research that will be conducted at the Pennington Center.

In evaluating the proposals, the committee considered whether the project could be completed within the time frame of 3 years covered by available funds, because there is no guarantee of further support after 1992. Another criterion of the committee was that the proposed project should include not only basic research but also health promotion. The committee also placed greater importance on projects related to needs with relevance to goals of the LSU's research program and the needs of the Army, e.g., the nutritional status of dependents and of combat and operational personnel. The focus of this research would be a departure from previous Department of the Army programs, which were related more to the soldier under field conditions.

In reviewing the proposals set before them by LSU, it would have been helpful if the committee had available to them a clear understanding of the research agenda within which the proposals were being presented. The committee would be reluctant to consider proposals with the absence of such a set of priorities in the future.

Following is the committee's evaluation of the research proposals presented to them and to Army personnel at the Pennington Center.

A proposal on Cardiovascular Health: Assessment and Intervention at Fort Polk was presented by Dr. Gerald Berenson from Louisiana State University Medical School, New Orleans, La. This proposal seemed to the committee to meet the criteria described above. Dr. Berenson proposes to focus on military service personnel and their families. His group will perform a health risk appraisal on these people upon entry into service at Fort Polk, monitor the effects of dietary intervention strategies, and evaluate the effectiveness of these strategies at the termination of service. The objective is to lower cardiovascular risk for both the soldier and the family. The proposed protocol is similar to the one that Dr. Berenson used in the Bogalusa Heart Study, wherein the effects of dietary intervention strategies on various health status parameters such as body weight, blood lipids, and blood pressure were measured.

The committee believes it would be useful to identify one or two health issues and concentrate on these, for example, to decrease the percentage of fat in the diet from 40% to approximately 25% or 30% of caloric intake and to achieve a 1-to-1 ratio of polyunsaturated fats to saturated fats. The committee believes that several people would need to be hired under the grant to do the analytical work, including laboratory and statistical analyses, at the Pennington Center rather than in New Orleans.

At present, the National Nutrition Monitoring System of DHHS focuses exclusively on the civilian U.S. population. This proposal would provide an excellent opportunity to do a related evaluation within the military community.

For all these reasons, the committee supports this proposal and encourages the U. S. Army Medical Research and Development Command (USAMRDC) to consider it seriously, but is concerned that the usual turnover of military personnel might present follow-up problems during the 3-year limit of the study.

The next presenter was Dr. Alfredo Lopez from LSU's Medical Center in New Orleans. The topic of his presentation was the relationship between vitamin A status and night vision. His research proposal focused on measuring the vitamin A status of the soldier either by monitoring dietary intake levels or by measuring serum levels of vitamin A. To demonstrate by intervention the relationship between increased vitamin A activity and

a decline in night blindness, however, he would need a population that evidenced vitamin A deficiency--a somewhat unlikely occurrence among the U.S. military community. Nevertheless, the committee believes that the proposed study has some relevance to military preparedness with regard to night blindness and dark adaptation. The study could be useful if improved methods to measure vitamin A status in the field would be one of the results. But overall, its relevance to the military mission appears marginal because of the relative absence of vitamin A deficiency. Thus, the committee recommends that this proposal not be considered at this time.

Dr. Marion Hegsted, Associate Professor in the Human Nutrition and Feeds Section of LSU's College of Agriculture in New Orleans, talked about the association of diet with cancer, osteoporosis, preeclampsia, and body weight status in female soldiers. Dr. Hegsted also discussed the U.S. military weight standards for women. There may be some distinction between women who exercise and those who do not in relation to osteoporosis. The committee noted that many female soldiers may approach the upper limit of acceptable body weight as determined by military standards. The question arose whether overweight women would resort to bulimia in order to keep their weight down. The committee concluded that these overweight women may constitute a susceptible overweight population, but that bulimia is a complicated illness rather than just a weight control measure. The committee agreed that Dr. Hegsted's comments were meritorious, but that they should be more specifically set forth and reasonable protocols developed.

The committee noted that the Army already had a collaborative effort under way in the area of stable isotopes with Dr. Dale Schoeller, University of Chicago. Therefore, the committee agreed to defer comment on Dr. Fryer's proposal at this time.

#### Conclusions and Recommendation

The committee concluded that the proposal submitted by Dr. Berenson comes closest to meeting the needs and mission of Army personnel and their dependents. A similar protocol has been used in the Bogalusa Heart Study--a longitudinal study that has been in progress for more than 20 years in Bogalusa, Louisiana. The committee suggests that Dr. Berenson seriously consider the transiency of personnel when he is designing his protocol.

The remainder of the protocols presented (see titles on agenda enclosed) appear to require more thought in design as they relate to military personnel and their dependents. Although several researchers presented "pilot" designs, the descriptions were limited, their directions were not clear, and the usefulness to the Army questionable at this time. Dr. Chandan Prasad of LSU's Medical Center was not able to present his proposal on Dietary Modulation of Mental Performance and Associated

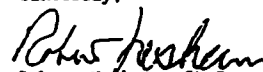
PENNINGTON CENTER - RESEARCH PLANS

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Neurochemical indices to the committee at this meeting. The committee believes that this proposal may have direct application for military personnel because of its potential significance to cognitive behavior and military preparedness.

The committee sees many interesting opportunities for the Pennington Center to become a center of research supporting military personnel and their dependents, but does not recommend that the program should in any way be intended as a replacement for the excellent ongoing program at USARIEM. For example, the committee suggests that the Pennington Center consider establishing a research laboratory where analytical research can be carried out that can provide nutritional assessment support to the program at Natick. The Pennington facility could be an important adjunct to long-term nutrition research efforts of the military.

Sincerely,

  
Robert Nesheim, Ph.D.  
Chairman  
Committee on Military  
Nutrition

Enclosures

cc: S. Thier  
S. Palmer  
D. Schnakenberg  
E. Askov  
S. Berkov

*Appendix E*

*Letter Report: Research Progress  
Review of the Pennington Biomedical  
Research Center, May 1992*



INSTITUTE OF MEDICINE  
NATIONAL ACADEMY OF SCIENCES  
2101 CONSTITUTION AVENUE WASHINGTON D.C. 20418

FOOD AND NUTRITION BOARD

(202) 334-1732  
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May 15, 1992

Major General Richard T. Travis  
Commanding General  
U.S. Army Medical Research and Development Command  
Fort Detrick  
Frederick, MD 21702-5012

Dear General Travis:

At the specific request of the COL Eldon W. Askew, Ph.D., Chief, Military Nutrition Division, U.S. Army Research Institute of Environmental Medicine (USARIEM) who is Grant Officer Representative of the US Army Medical Research and Development Command (USAMRDC) for Grant no. DAMD17-86-G-6036 to the National Academy of Sciences for support of the Food and Nutrition Board's (FNB) Committee on Military Nutrition Research (CMNR), the CMNR met at the Pennington Biomedical Research Center in Baton Rouge, Louisiana on Sept. 19-20, 1991. The purpose of this meeting was to assist the Army in reviewing and evaluating the progress on work related to the USAMRDC Grant no. 17-88-Z-8023: "Effect of Food, Diet, and Nutrition on Military Readiness and Preparedness of Army Personnel and Dependents in a Peacetime Environment".

This Grant was established to implement this program for which funds were specifically allocated through the House Authorization Committee (DOD Appropriations Bill, 1988). An important consideration in the initiation of the Army funded program was that these funds were allocated for a 3 year period and the Pennington Center was not yet staffed or equipped. Initial proposals for one of these funds were developed by Louisiana State University (LSU) largely drawing on the interests and personnel available from the LSU Medical Center. As discussed in the letter report dated June 26, 1989, to Major General Philip K. Russell (see attachments), the Committee reviewed these proposals which were quite preliminary in nature. The proposal by Dr. Gerald Berenson came closest to meeting the criteria established in the Appropriations Bill. The Committee also recognized the value of establishing a research laboratory which could provide analytical support to the nutritional assessment program conducted by the Nutrition Research Group at Natick Laboratories.

The Committee on Military Nutrition Research's role in this preliminary review was to assist the Army with identifying research activities that fell within the mandate of the appropriation with the responsibility for the final decisions in program and funding with the Army.

Prior to assembling at the Pennington Biomedical Research Center, the CMNR reviewed: 1) an information paper and background materials, including the Grant Statement of Work, provided by COL Askew, the Grant Officer Representative; 2) the Final Report on USAMRDC Grant to the Pennington Center submitted by the principal investigator, Donna H. Ryan, M.D.; and 3) an earlier report prepared by the CMNR at the request of the USAMRDC reviewing this same research program in 1989. Copies of the information papers, the 1989 report from the CMNR, plus the meeting agenda and list of participants are attached.

On September 19, 1991 the CMNR convened at the Pennington Biomedical Research Center (PBRC) and heard presentations of the research accomplishments during the grant period from the Center staff and a statement from COL Askew. On September 20, 1991 the Committee met in executive session and reviewed the accomplishments of the Pennington Biomedical Research Center over the grant period in relation to the grant Statement of Work, the goals of the principal investigator, and their own previous recommendations. To provide supplemental expertise to the Committee membership in the area of neurotransmitters, the CMNR also submitted a copy of that part of the annual report of the Pennington Biomedical Research Center grant dealing with Project No. 3, Diet, Neurotransmitters, and Behavior, to two scientists currently working in this research area for confidential review. The Committee included the review of this outside team in their deliberations when writing this report. All CMNR members present at the meeting have seen and approved the report. Subsequent to approval of the final draft by the Committee, in accordance with National Research Council guidelines, this report was reviewed in confidence by a separate anonymous scientific review group. The Committee and advisors have reviewed the anonymous comments of this review panel and incorporated their suggestions where appropriate. Staff has then written a letter of response to the reviewers with the final report draft and obtained final approval of the report from the review panel. This report is thus a thoughtfully developed presentation that incorporates the scientific opinion of the CMNR, and the anonymous National Research Council reviewers.

Following is the Committee on Military Nutrition's evaluation of the research program presented to them and to Army personnel at the Pennington Biomedical Research Center.

#### General Comments

The Pennington Biomedical Research Center is a very impressive facility having an excellent physical plant for laboratory and clinical research. Considerable progress has been achieved in staffing and development of research activities since the CMNR's last visit on December 12, 1988. This has been made possible by financial support from the U.S. Army, USDA, and grants from NIH and other sources. In addition, the state of Louisiana has provided ongoing support at a level of \$4.1 million dollars.

It is worthy of note that the new director for the PBRC, George A. Bray, M.D., has been appointed since the Committee's last visit. Dr. Bray, who is internationally renowned for his research in the fields of obesity and energy metabolism, has provided an important vision for the Pennington Center (which he is moving rapidly to bring to fruition). The progress noted builds effectively on the initial framework established by Dr. Allen Copping, President of the Louisiana State University (LSU) system, and on the ongoing administrative support of Donna H. Ryan, M.D., Project Director for the Military Nutrition Grant.

In general the Committee found that there was effective management support and guidance for the development of activities related to this grant. The progress in each project area was reviewed by the Committee and its assessment follows.

#### Specific Project Reviews

Project No. 1: Clinical Research Lab. This project is headed by Richard Tully, Ph.D. The major objective of this project was to provide biochemical assessment of nutrition status and to perform food biochemistry analysis. Significant progress has been made in securing necessary analytical equipment, implementing appropriate analytical procedures and most importantly, in implementing a sound quality assurance program. Dr. Tully has made significant progress in activating an effective clinical laboratory in a short period of time and in utilizing this facility to support requests from USARIEM. It should be noted that all of this has been accomplished with limited staff support.

The Committee is of the opinion that the Clinical Research Lab is a valuable resource to the Pennington Biomedical Research Center as well as being extremely valuable to USARIEM. The nutrition group at USARIEM has previously experienced difficulty in obtaining accurate and timely analytical information from outside contract laboratories. The ability to obtain important analytical data on military nutrition research projects in a timely manner greatly enhances the effectiveness of the nutrition research program. We recommend that the U.S. Army continue to provide partial support for this activity with the understanding that this resource be available on a priority basis to support U.S. Army studies. Further, the Committee supports the provision of additional resources to increase staffing of the Clinical Research Lab.

The staff of the Pennington Center has indicated a desire to develop a food analysis capability. The Committee recognizes the need for food analysis to support the clinical studies which the Center anticipates undertaking. In order to develop this capability effectively it is important to add an experienced food chemist to the Pennington Center staff. A major food analysis program would consume considerable resources both for methods development and actual analysis of various food components. Further, the undertaking of food analysis will require significant equipment additions and the staff should make judicious decisions regarding what analyses need to be performed beyond proximate analysis and inorganic elements. The CMNR believes that the breadth of activity necessary to establish a high quality food analysis laboratory would involve significantly more expertise, resources (equipment, personnel, and supplies), and facilities than is currently projected at the Pennington Biomedical Research Center. The Committee therefore holds that limited analysis on foods, related specifically to electrolyte balance, may be more within the scope of the laboratory's capabilities.

Project No. 2: Stable Isotope Lab. This project is directed by James P. DeLany, Ph.D. who has a good background in the use of stable isotopes to measure energy expenditure and body composition. The stable isotope technique provides a unique approach for use in free-living subjects since it is non-invasive and nondestructive. Consequently, it provides an ideal means of assessing important endpoints in experimentation valuable to the military.

The equipment that has been purchased and installed is state-of-the-art allowing Dr. DeLany to establish his methods and rapidly gear up his laboratory to support multiple studies. The Committee was favorably impressed with the quality and quantity of work completed thus far. In view of the expanding nature of military research projects which utilize stable isotopes in their protocols, the Committee recommends continued funding of the Stable Isotope Laboratory for priority support of military studies.

The staff of the Pennington Center have indicated a desire to increase the staffing of the laboratory by one additional Ph.D. scientist. In view of the importance of this methodology, the Committee would encourage such an addition if possible.

The availability of stable isotopes required for this work is currently limited and could curtail the ability to adequately support this area of research by the military as well as other investigations. The CMNR recommends that the military encourage the development of an adequate supply of the necessary stable isotope through combined efforts of the federal research establishment.

Project No. 3: Diet, Neurotransmitters and Behavior. This project is directed by Chandon Prasad, Ph.D. and has been staffed during the project period with five additional scientists on full or part time basis. In addition nine students have participated part time over the project period. The efforts to date have been devoted to developing the methodology for studying the effect of diet on behavior in animal models.

The CMNR believes that the area of nutrition and behavior is of military relevance, but the current research effort lacks focus and appears to have limited applicability to military concerns. The Committee is of the opinion that there is a need to further explore appropriate, relevant areas of research at the physiological and cellular level that are pertinent to military applications. This would require a reorientation of the current effort with considerably greater focus. It is suggested that the researchers develop more specific hypotheses which then can be investigated to better target the projects and to better determine the relevance to the military. The Committee notes that 25 percent of the funding provided by the Army has been in support of the research program of Dr. Prasad. The military has a major interest in the potential influence of nutrition on behavior particularly in those areas that may improve or maintain cognitive performance under combat stress. With the increasing sophistication of weapons systems there is a need to increase the capability of the individual to maintain mental acuity to function with these systems.

The lack of focus can be illustrated by listing the titles of the 15 projects reviewed. These were: 1) Behavioral neurochemistry of food-derived peptides; 2) Cyclo (His-Pro) and food intake; 3) Determination of tryptophan metabolites using HPLC; 4) Preparation and characterization of dopamine ( $D_2$ ) receptor protein antibody; 5) Determination of dopamine ( $D_2$ ) receptor messenger RNA expression; 6) Dopamine ( $D_2$ ) receptor protein antibody mapping in the rat brain; 7) Dietary protein and behavior in rats; 8) Levels of dietary protein and modification of behavioral responses to CNS acting drugs; 9) Dietary protein and dopamine receptor regulation; 10) Effects of dietary protein on monoamines and monoamine metabolites; 11) Dietary protein and preparatory arousal in rats; 12) Dietary protein and neuronal plasticity; 13) Dietary protein and microtubule-associated proteins; 14) Dietary protein and brain amino acid profiles; and 15) Diet and stress.

Many of the studies involved the effect of dietary protein in brain chemistry neuronal structure and behavior. Most of these studies involved feeding rats diets up to 50% protein. In view of the vast literature involving studies of dietary protein in brain development and behavior in rats, the value of still more rat studies to the military has not been justified. In particular, the use of diets supplying 50% casein is questionable and of little relevance to human feeding in or out of the military. Several of the projects appear to be "fishing expeditions".

It is important that the research conducted under this program be well focused in order that its relevance can be evaluated both in long term and in applications to the near term. The CMNR recommends that a special site review be conducted in which efforts are undertaken to delineate major Army needs and review the Pennington Biomedical Research Center's program in light of responding to those needs with highly focused research. It is recommended that the site review team be composed of individuals who work directly in the area of nutrition, cognition, and behavior with expertise in the field of neurotransmitters.

Project No. 4: Fort Polk Study. The director of this study is Gerald S. Berenson, M.D. who initiated and developed the Bogalusa Heart Study. The project was completed in August 1991. The objective, as presented to the CMNR, was under the general title "Health Promotion Research and Assessment", and is "Assessment of Nutritional Status and Cardiovascular Risk of Military Dependents." While the Committee did not necessarily give this the highest priority rating in 1989, it was a project that could be implemented immediately. The study has achieved the objective of doing an nutritional/health risk appraisal of military dependents.

The second component of the Fort Polk Study was the development of a health promotion/education program for military families. It was unfortunate that the study did not have a larger sample size ( $n = 70$  families) in the three cycles of families involved in the health promotion/education component. In addition, there was not a control group established for this component of the project. The CMNR also noted that the project report did not include any evaluation of the effectiveness of the program either on a short-term or long-term basis. For example, there was no measurement of changes from baseline measurements in behavior or other status indices.

It is the understanding of CMNR that this project has been completed, and future funding is not planned under this program. The CMNR would concur with this position. In the event that future plans might evolve to include implementation of such a health promotion program for military dependents, it is the position of the CMNR that a thorough review of the results of this study and delineation of desired objectives, including inclusion of methodology to evaluate long-term outcomes, should be conducted prior to implementation.

Project No. 5: U.S. Army Menu Modification Project. This project has been carried out by Evelina W. Cross, Ph.D. and Catherine Champagne, Ph.D. The results presented at the CMNR review were very preliminary, and the research team has been granted a no-cost extension to complete the requirements of the contract.

It is the consensus of the CMNR that the investigators were not sensitive to the needs of military garrison feeding program as demonstrated by the preliminary menus provided at the review. The project did not demonstrate any application of menu planning guidelines that would be appropriate in the military menu system, in terms of cost, acceptability, color, etc. Their first phase of menu modification did not meet the objectives of the project; the second phase brought fat down from 40 to 36% (not 30%), but did not appreciably reduce sodium or cholesterol (except when substitutions were made for breakfast eggs). The menus developed initially decreased caloric intake from 3,500 to 3,030 kcal. This lowered caloric intake might be considered a problem in some garrison situations. The menus developed to date and presented to the CMNR did not address cost, appearance, national food preferences, or relevance to the military feeding system.

The CMNR also questions whether the evaluation procedures used (college students consuming a meal as opposed to sensory evaluation panels, etc.) were applicable to the eventual user. Although the project was incomplete when reviewed, the CMNR was not impressed with some of the approaches taken. The Committee further viewed the lack of interaction between the menu developers and the military menu system as a serious constraint on the ability of the investigators to achieve their objectives.

Therefore the Committee believes that this project, if continued, should be conducted in a military facility where the staff is more familiar with the military menu and procurement systems in order for a practical program to be developed.

Overall Conclusions and Recommendations

Generally, the Committee was impressed with the quality of the research activities at the Pennington Biomedical Research Center given the constraints of essentially starting from a zero base in equipping the facilities, recruiting staff, and initiating research activities, and felt that the funds provided by the U.S. Army grant had been effectively deployed. The CMNR would encourage continued financial support by the U.S. Army of those activities which have been and can continue to be relevant to the military namely the Clinical Research Laboratory and the stable isotope activity. Further, support of the area of nutrition and behavior should continue with attention to developing a project with greater focus and hence military relevance.

Sincerely,

  
Robert O. Nesheim, Ph.D.

Chairman  
Committee on Military Nutrition  
Research (CMNR)

Enclosures

cc: K. Shine  
C. Woteki  
D. Schnakenberg  
E. Askew  
B. Marriott

## *Appendix F*

**Summary and Recommendations  
from the Workshop Report: *Fluid  
Replacement and Heat Stress***



## **FLUID REPLACEMENT AND HEAT STRESS**

**A Report of the Proceedings of a Workshop  
Committee on Military Nutrition Research**

**INSTITUTE OF MEDICINE**

**Food and Nutrition Board**

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Editors, Second Printing**

**National Academy Press  
Washington, D.C. 1991  
Second Printing  
(with minor revisions)**

## COMMITTEE SUMMARY AND RECOMMENDATIONS

### Introduction

Advances in our understanding of the value of carbohydrate-electrolyte solutions have come from information derived from two major fields of study—exercise physiology and sports nutrition—and from research on diarrheal diseases. Research in the first area has been concerned with physical performance, primarily of athletes. Research results have demonstrated that even small fluid deficits have adverse effects on performance through elevated heart rates, reduced sweat rates, and elevated body temperature. Glucose-electrolyte solutions have been found useful in rehydration and in preventing dehydration. Carbohydrate is needed to facilitate sodium and water absorption. Other ions may or may not be needed, depending on sweat losses or losses from the gastrointestinal tract. Advances in exercise physiology also have demonstrated the value of carbohydrate solutions in providing energy for muscular activity in endurance events that last at least 60 minutes and involve vigorous exercise.

Diarrhea is a major, perhaps the most important, contributor to death of infants and preschool children in less-developed countries. Death rates are being reduced around the world through the use of oral rehydration therapy (ORT), which involves the use of carbohydrate-electrolyte solutions and is based on the same basic physiologic mechanism as the rehydration solutions given to athletes, i.e., the provision of glucose to promote the absorption of sodium and potassium ions and of water.

Both these established uses for carbohydrate-electrolyte beverages have potential military applications. Military personnel are often called upon to perform heavy physical activity during training or combat conditions in very hot environments—either dry climates, as in Middle-Eastern deserts, or under humid tropical conditions. The resultant high sweat rates can lead to dehydration. In some cases, the subjects may be acclimated to heat, but in others (for example, in basic training, or in emergency troop deployment to the tropics) they may not, and may thus be vulnerable to extensive electrolyte losses. This problem could be accentuated when personnel have been given garrison or field rations with reduced sodium to meet prudent dietary goals established for the general population in 1989 by the Diet and Health Committee of the Food and Nutrition Board, National Academy of Sciences.

A carbohydrate-electrolyte beverage could be useful in providing glucose to sustain muscular activity in troops involved in heavy physical activity for long periods. Recognizing that the maintenance of an adequate hydration status is dependent on an adequate fluid intake, the military has for a long time instructed troops on ways to maintain a safe supply of drinking water under field conditions. Carbohydrate-electrolyte solutions are useful in rehydration during episodes of diarrhea, especially to counteract acute dehydration that results when diarrhea occurs in conjunction with heavy sweat losses.

#### **Findings from the Workshop Presentations**

Maintaining an adequate state of hydration is important for the maintenance of high levels of physical performance by soldiers in the field. At a 3% decrease in body weight due to dehydration, there is a substantial decrease in physical working capacity. The maintenance of adequate fluid intake is of primary importance in the prevention of hypohydration that may otherwise occur under such conditions as prolonged air travel, extended working hours, wearing of chemical protective clothing, missed meals, or working in mountainous areas or in hot or extremely cold environments. Increased psychological stress associated with basic or field training exercises or anticipation of combat or actual combat may lead to extreme hypohydration due to decreased voluntary fluid intake. Conscious efforts to increase fluid intake before and during such situations could prevent this condition. Training and the initiation of disciplined programs to increase both voluntary and programmed fluid intake are important preventive actions.

Heavy physical activity, especially in hot environments, and wearing of protective clothing promote sweating and will lead not only to excessive fluid losses but also to associated electrolyte losses. Sodium, potassium, and chloride losses in sweat are affected by temperature, humidity, and state of acclimatization. Febrile conditions or gastrointestinal disturbances, particularly those associated with vomiting and diarrhea, may result in significant fluid and electrolyte losses and require replacement of electrolytes in addition to fluid. Gastrointestinal losses may also include hydrogen ion, bicarbonate, magnesium, and other cations and anions, depending on the cause of the losses and the severity of the disturbance.

Glycogen depletion from muscle and liver may result from prolonged physical exercise—more than 60 or 90 minutes at 60% to 70% of exercise capacity or several hours at lower exercise intensities. Such depletion may

be aggravated by poor nutritional intake of carbohydrates, inadequate periods of recovery from previous glycogen-depleting exercise, and sustained negative calorie balance. Under these conditions, soldiers may benefit from consuming fluid replacement beverages containing carbohydrates. This is particularly true if food intake is inadequate, resulting in significant caloric deficit or limited carbohydrate intake. The resultant reduced muscle and liver glycogen content will result in earlier fatigue and slower recovery.

It is evident from the research reported at this workshop that a fluid replacement solution may play an important role in preventing fluid, electrolyte, and glycogen depletion, thereby maintaining or improving a soldier's performance. It is also evident that the composition of the replacement fluid might well vary, depending on the physical demands of the military activity and the environmental conditions under which the activity is undertaken.

Water intake is the primary requirement to ensure adequate hydration during psychological and environmental stress *not associated with intense physical activity* and during sedentary activity at high altitudes. If a normal meal pattern is established and fluid is consumed, the body's balance is restored.

Palatability of the fluid replacement solution is important to ensure compliance. This may be enhanced by appropriate coloring and flavoring. The solution should also be compatible with halogens to make it possible to use halogen-treated water in the preparation of the solutions.

#### Areas for Future Research

The participants whose papers appear in this volume provided an excellent review of the current state of knowledge on fluid replacement and stress. These proceedings will provide investigators and product formulators with important guidance in the development and testing of electrolyte-carbohydrate-containing fluid replacement products for use by the military. Continued research is needed on energy, electrolyte, and fluid requirements in different environmental and operational conditions that require different types of physical activity. More studies are also needed to provide us with a better understanding of (1) the factors affecting liver and muscle metabolism and injury during heat stress, and (2) the factors that are important in preventing muscle injury during heat stress and in enhancing muscle recovery. The following issues raised at the workshop could lead to a better understanding of the appropriate composition and usage of a fluid replacement beverage:

- What are the effects of food in the small intestine on fluid and electrolyte absorption? How are fluid and electrolyte absorption affected relative to timing of meals?
- What are the effects of hypohydration on the absorption of electrolyte-carbohydrate solutions?
- What factors regulate depletion of muscle and liver glycogen stores during negative caloric balance or prolonged physical activity?
- What is the role of glycogen depletion in the fatigue of different muscle groups? What other factors related to beverage composition determine muscular fatigue?
- What factors determine the rate of glycogen depletion and resynthesis? There is a need to obtain quantitative data on the effects of feeding and the provision of electrolyte-carbohydrate solutions in maintaining glycogen stores and enhancing replenishment of glycogen stores following glycogen-depleting physical activity.
- What are the effects of fluid and electrolyte deficits combined with elevations in body temperature on cognitive and mental function?
- What factors need to be considered in product development and water purification techniques to provide compatible systems for field use under a variety of environmental and operational conditions? Factors such as halogen or other purification requirements and the composition of local water supplies need to be considered in relation to formulation of practical electrolyte-carbohydrate mixtures.
- What effect would result from the provision of an electrolyte-carbohydrate replacement solution on soldiers who previously consumed a low-sodium diet?
- Will the addition of specific amino acids such as glycine be beneficial in enhancing sodium and water absorption?

#### **Recommendations**

When used appropriately, electrolyte-carbohydrate-containing beverages appear to have the potential not only for maintaining but also, possibly, for enhancing performance and endurance in a variety of military situations. The specific needs for water, electrolytes, and carbohydrate may vary somewhat depending on the specific circumstances in which the solution is used. The ideal solution would be one that could be diluted in different ways to meet the relative specific needs of the personnel.

The goal of using such a solution should be to maximize fluid intake, replace electrolyte losses, and provide a carbohydrate source for

energy and rapid replenishment of muscle and liver glycogen stores during and following physical activity. The use of an electrolyte-carbohydrate-containing beverage may be applicable to a number of circumstances in the military such as the following:

- Maintaining adequate fluid intake prior to military operations during which voluntary dehydration is probable.
- Providing fluid, electrolyte, and carbohydrate replacement during physical work in a variety of environmental conditions, including high temperatures, humidities, or wearing of chemical protective clothing. In such situations, sweat rates are high and account for large fluid and electrolyte losses.
- Providing rapid rehydration following heavy or prolonged physical work, thereby facilitating recovery from heat injury.
- Providing carbohydrate during and following physical activity to maintain plasma glucose concentrations, furnishing carbohydrates for energy, and enhancing replenishment of glycogen stores during postoperational recovery.
- Replacing gastrointestinal losses due to vomiting or diarrheal diseases.

The committee recommends that the Surgeon General of the Army evaluate the use of electrolyte-carbohydrate fluid replacement products as an aid to maintaining proper hydration of soldiers during periods involving psychological and environmental stress and also assess the effectiveness of these products in maintaining or enhancing both physical and cognitive performance during training activities and field operations.

Physical demands and adverse environmental conditions that occur during military training and operations may lead to any one or all the conditions summarized above. In view of this, the committee concludes that there are circumstances in which the performance of military personnel would be improved by appropriate use of electrolyte-carbohydrate solutions under field conditions.

Below are the committee's recommendations developed following the workshop:

- The solutions should provide approximately 20 to 30 meq of sodium per liter, 2 to 5 meq of potassium per liter, and chloride as the only anion.
- The carbohydrate content should be provided as glucose or sucrose, malto-dextrin, or other complex carbohydrate in a concentration of 5% to 10%.

- The value of additional magnesium, bicarbonate, and phosphate to compensate for gastrointestinal losses due to diarrhea or other gastrointestinal disturbances should be determined.
- The promotion of fluid intake with such palatability and psychogenic aids as flavorings and colorings should be evaluated with respect to the promotion of fluid intake. The components of the solution must be compatible with halogens or other water purifiers.
- A variety of training and field operations should be considered as a means for evaluating the effectiveness of prototype electrolyte-carbohydrate-containing solutions under the following conditions:
  - When soldiers are in significant negative caloric balance.
  - Under conditions of hypohydration.
  - When the solution is the principal beverage available.
  - Under conditions of environmental extremes, especially those conducive to stress. Interventions for prevention and therapy of heat-related disorders should be evaluated.
  - When used by soldiers previously on a low sodium diet (less than 3 g/day) who are suddenly exposed to hot or humid environments and who are performing heavy physical activity.
  - Under field conditions when halogen-treated water is likely to be available. Do any of the components in the prepared solution interfere with purification of the water? Is the resulting beverage sufficiently palatable to ensure an intake adequate to prevent significant hypohydration?

## *Appendix G*

Summary and Recommendations  
from the Brief Report: *Military  
Nutrition Initiatives*



**Military Nutrition Initiatives**

**A Brief Report Submitted by**

**The Committee on Military Nutrition Research**

**Food and Nutrition Board**

**Institute of Medicine**

**to**

**Major General Richard T. Travis**

**Commanding General**

**U.S. Army Medical Research and Development Command**

**February 25, 1991**

**Produced under grant number DAMD17-86-G-6036/R between the National Academy of Sciences and the U.S. Army Medical Research and Development Command.**

## Military Nutrition Initiatives

### Introduction and Background

The Military Nutrition Division of the U.S. Army Research Institute of Environmental Medicine (USARIEM) asked the Committee on Military Nutrition Research (CMNR) to review the significant reports recently published dealing with Nutrition and Health and to consider how their recommendations pertain to the nutritional policies and practices of the military. During parts of two meetings of the CMNR on December 8, 1989 and June 28-29, 1990 the recommendations of: the Diet and Health Report of the Food and Nutrition Board (1), the Surgeon General's Report on Diet and Health (2), and the Year 2000 Health Objectives for the Nation (3) were reviewed by representatives of these agencies. The CMNR was also briefed on the results of dietary surveys conducted over the past few years at several military installations. In addition, a presentation of some of the activities in the promotion of sound nutrition and health programs for Army personnel was provided for the information of the Committee. The Committee was unable to complete its discussion and evaluation at the December 8, 1989 meeting and the review was completed at the June 28-29, 1990 meeting. In the Appendices to this report are the agendas, references, briefing materials, presentation graphics and excerpts from the minutes of these two meetings.

The Committee believes that the most definitive dietary recommendations are provided in the report of the NAS/NRC Committee on Diet and Health (1). The nine specific recommendations of this report are as follows [Excerpted from The Executive Summary of Diet and Health (1), pp 10-15.] :

1. Reduce total fat intake to 30 percent or less of calories. Reduce saturated fatty acid intake to less than 10 percent of calories, and the intake of cholesterol to less than 300 milligrams daily.
2. Every day eat 5 or more one-half cup servings of a combination of vegetables and fruits, especially green and yellow vegetables and citrus fruits. Also, increase intake of starches and other complex carbohydrates by eating 6 or more daily servings of a combination of breads, cereals, and

legumes. Carbohydrates should total more than 55 percent of calories.

3. Maintain protein intake at moderate levels -- that is, approximately the current Recommended Dietary Allowance (RDA) for protein, but not exceeding twice that amount or 1.6 grams/kilogram of body weight for adults.
4. Balance food intake and physical activity to maintain appropriate body weight.
5. The Committee does not recommend alcohol consumption. For those who drink alcoholic beverages, the Committee recommends limiting consumption to the equivalent of less than 1 ounce of pure alcohol in a single day. This is equivalent to 2 cans of beer, 2 small glasses of wine, or 2 average cocktails. Pregnant women should avoid alcoholic beverages.
6. Limit total daily intake of salt to 6 grams or less. Limit the use of salt in cooking and avoid adding it to food at the table. Salty, highly processed salty, salt-preserved, and salt-pickled foods should be consumed sparingly.
7. Maintain adequate calcium intake.
8. Avoid taking dietary supplements in excess of the Recommended Dietary Allowances in any one day.
9. Maintain an optimal intake of fluoride, particularly during the years of primary and secondary tooth formation and growth.

#### **Committee Recommendations**

The CMNR reviewed the nine dietary recommendations of the NRC Committee on Diet and Health as they pertain to the nutritional policies and practices of the military. In general, the Committee endorsed the recommendations as being applicable to the military with the exception of the recommended level of sodium intake, that was considered to be too low

for military requirements. The Committee made the following specific comments concerning the implementation of the Diet and Health recommendations by the military.

1. The CMNR recommends that the goal for military personnel should be to reduce their total fat intake to 30 percent or less of total calories, to reduce saturated fatty acid intake to less than 10 percent of calories, and cholesterol intake to less than 300 mg/day. This goal is appropriate for garrison feeding. To accomplish this, there should be a program of continued education of military personnel and their families as to appropriate food choices and an evaluation of possible menu changes and/or portion sizes in the military food service program. It was agreed, however, that a full range of food choices should be maintained in garrison settings and that the primary emphasis should be on educational programs to modify diet rather than limiting availability of specific high fat food items. The Committee acknowledges that it is not realistic to expect the military to reach this goal at a rate much faster than the civilian population of similar demographic characteristics, since military personnel in garrison have similar options for food selection either through choosing to eat in military dining facilities, at home, or in readily available food service options in the community. The Committee recommends that the emphasis should be on alternative food selections available in the mess halls to allow individuals to meet this goal, for example, in addition to low fat and whole milk, skim milk could regularly be available as well as regular and low fat salad dressings. In garrison food preparation, meats should be trimmed and gravies and sauces prepared with inclusion of low-fat products wherever possible.

The Committee was pleased to note that actions taken by the military over the past several years through nutrition education programs and policy changes, apparently are showing considerable progress toward achieving the goal of reducing total fat intake. This is illustrated by comparison of studies conducted prior to initiating the nutrition education program that showed a range of 41.8 to 48.6% of calories consumed from fat with a study that showed a range of 38.4 down to 34.0% of calories from fat in 1988 after the education program had been implemented. These data indicate progress in reduction of dietary fat intake that is not appreciably different from comparisons with the U.S. civilian population. (See the summary chart on page 7.) While the methods used to collect the data presented in this table are not directly comparable, the trends illustrated in the military studies are similar to that shown for the U.S. civilian population.

Presumably, this reduction in fat was replaced primarily by carbohydrate food sources. The Committee does not feel that it is necessary to further alter menus or recipes to reduce the dietary fat content, particularly where acceptance of the food item is compromised. Instead, extensive nutrition education should be continued so the soldier can make informed food choices leading to a higher proportion of energy from carbohydrate. Educational programs should include specific suggestions regarding healthy snack choices. These programs need to incorporate the availability of alternative snacks such as fresh fruit, low fat yogurt, low fat and low salt snack items in vending machines.

The recommendation concerning limiting cholesterol intake to not more than 300 milligrams per day presents the greatest challenge to military nutrition programs due to the preference for eggs in the breakfast menu in garrison feeding. The Committee recommends the continued inclusion of eggs in the menu, but emphasizes that low cholesterol breakfast alternatives should be available and attractively presented.

2. The Committee on Diet and Health recommended a daily intake of 5 or more one-half cup servings of a combination of vegetables and fruits, especially green and yellow vegetables and citrus fruits. Concern was expressed that this goal may be difficult to achieve without some changes in monetary ration allowances to permit the purchase and storage of larger quantities of fresh vegetables and fruits. However, it should be clear that frozen or canned vegetables and fruits are an acceptable alternative in meeting this objective.

An intake of 6 or more daily servings of a combination of breads, cereals and legumes was recommended by the Committee on Diet and Health. Carbohydrates should provide a total of 55% or more of total calories. To meet this goal consideration should be given to the expansion of the number of starch selections, such as bean and pasta entrees, available at each meal, as well as offering several different bread choices.

3. As the proportion of energy derived from carbohydrate increases, the percent calories from protein will decline. This is in line with the Diet and Health recommendation that protein intake be maintained at a moderate level, i.e. approximately 0.8 g/kg body weight and not to exceed 1.6 g/kg body weight. For a 70 kg man this translates to an intake of 56 to 112 grams of protein per day. This level of dietary protein is sufficient to support good physical performance and also to allow an increase in lean

tissue with training. Dietary carbohydrates are readily used for fuel during physical activity; a high carbohydrate diet supports good physical fitness.

4. Total caloric intake should be adjusted to achieve and maintain military body weight and body composition standards. Specific goals and recommendations may be developed as a result of a CMNR workshop on body composition that took place in February, 1990. (The report based on this workshop is currently in preparation.)

5. The CMNR considered the Committee on Diet and Health recommendation of 6 grams or less of salt intake per day for the general population to be too low for military purposes. This is due to the potential risk of producing sodium depletion under some conditions, particularly exposure to a hot environment without an adequate period of adaptation. The Committee therefore recommends that the total daily intake of salt should be limited to 10 grams or less, except under conditions in which salt requirements exceed these values due to large salt losses such as those associated with heavy physical work in hot environments. Appropriate limitation on the use of salt in menu preparations consistent with adequate food acceptance and avoiding additions to food at the table should permit the achievement of this goal.

6. Dietary calcium is necessary for adequate growth and skeletal development. Recent research shows that bone growth continues through the third decade of life. Women, because of their low caloric intakes and increased risk of osteoporosis, especially need to make careful food choices to obtain an adequate calcium supply. The Committee recommends the following:

a) a nutrition education program be established for military women that emphasizes the importance of dietary calcium, and how to select calcium-rich foods; and

b) the provision of low-fat, calcium-rich food choices in the mess halls. Some of the following alternatives to whole milk might be considered for garrison feeding programs: dark green vegetables, low-fat frozen yogurt, and low-fat cheeses.

7. The CMNR endorses the recommendations of the Committee on Diet and Health regarding use of alcoholic beverages, dietary supplements, and optimal intake of fluoride, as appropriate for the military.

8. The nutrition recommendations from the Surgeon General's Report on Nutrition and Health are compatible with the Committee on Diet and Health 1989 recommendations discussed above.

9. The Committee has reviewed the Year 2000 Health Objectives for the Nation. The Committee finds no significant inconsistencies with the above recommendations and the nutrition objectives contained therein.

The Committee on Military Nutrition Research is pleased to note the interest of the military in promoting good nutrition, in improving the nutritional quality of military rations, and in efforts in nutrition education to help soldiers select diets consistent with current knowledge relative to healthy eating practices.

#### References

1. NRC (National Research Council). 1989. Diet and Health, Implications for Reducing Chronic Disease Risk. A report of the Committee on Diet and Health, Food and Nutrition Board, Commission on Life Sciences. National Academy Press, Washington, D.C. 749 pp.
2. DHHS (U.S. Department of Health and Human Services). 1988. The Surgeon General's Report on Nutrition and Health. U.S. Government Printing Office, Washington, D.C. 727 pp.
3. DHHS (U.S. Department of Health and Human Services). Promoting Health/Preventing Disease: Year 2000 Objectives for the Nation. Draft for public review and comment, September, 1989. U.S. Government Printing Office, Washington, D.C.

## Trends in Total Fat Intakes in Military Dining Facilities

<u>PRE-INITIATIVES</u>		<u>POST-INITIATIVES</u>	
	<u>% Fat Cals</u>		<u>% Fat Cals</u>
1952 FT SHERIDAN	46.0	1986 FT RILEY	37.6
1953 FT RILEY	48.6	1986 FT LEWIS	38.4
1966 FT HUACHUCA	45.5	1987 FT DEVENS	38.2
1971 LOWRY AFB	42.5	1988 FT JACKSON	
1976 US ARMY MIL ACAD	41.8	Males	34
1977 USS SARATOGA	42.1	Females	34
<u>Comparison to USA Civilian Population</u>			
1977-78 USDA NFCS		1985-86 USDA CFS II	
Males 20-29 yrs	41	Males 20-29 yrs	36
Females 20-29 yrs	40	Females 20-29 yrs	36
1976-80 NHANES II			
Males 20-29 yrs	36		
Females 20-29 yrs	36		

FIGURE 6. from the set of presentation graphics for: "Current U.S. Army Dietary Intakes of Fat, Cholesterol and Sodium" as presented to the Committee on Military Nutrition Research by LTC E. Wayne Askew, Ph.D., December 8, 1989.



## *Appendix H*

### **Summary and Recommendations from the Brief Report: *The New Generation Survival Ration***

**The New Generation  
Survival Ration**

**A Brief Report Submitted**

**by**

**The Committee on Military Nutrition Research**

**Food and Nutrition Board**

**Institute of Medicine**

**National Academy of Sciences**

**to**

**Major General Richard T. Travis**

**Commanding General**

**U.S. Army Medical Research and Development Command**

**February 13, 1991**

**Produced under continuation of grant number DAMD17-86-G-6036/R  
between the National Academy of Sciences and the U.S. Army Medical  
Research and Development Command.**

## **The New Generation Survival Ration**

### **Introduction and Background**

The U.S. Army Natick Research Development and Engineering Center (USANRDEC) has been asked to update the old General Purpose Survival Packet. This packet was type classified in 1961 and has not been updated since its initial procurement. Limited procurement quantities apparently have contributed to problems in obtaining several components as well as the tin-plate can that was part of the original design.

The Committee on Military Nutrition Research (CMNR) (See committee roster in Appendix I) of the National Research Council's Food and Nutrition Board was asked by the Nutrition Research Division of the U.S. Army Institute of Environmental Medicine (USARIEM) and USANRDEC to review the proposed nutrition standards for the New Generation Survival Ration to determine if they were consistent with current scientific knowledge. The USANRDEC provided the CMNR with an overview of the project, including the critical nutrient specifications and expected conditions of storage and use at the meeting of the CMNR on June 28-29, 1990 at Natick, Massachusetts. The committee examined and tasted the ration product under current development and toured the USANRDEC and USARIEM research buildings where they were shown the facilities for development and testing of both the ration components and its packaging. Copies of the briefing materials and additional military reference materials related to survival rations were provided to the committee and are included in Appendix II.

Briefly, the nutrition requirements for the survival ration are that it should provide adequate carbohydrate to prevent ketosis and be low in protein content to conserve water needs. In addition, the ration must be shelf stable at high temperature storage (five years at 80°F and one month at 140°F), require no preparation, and be sufficiently acceptable to have a positive effect on morale. Since the survival ration is designed to be consumed for a period of less than five consecutive days, the nutrient standards for operational rations do not apply.

The CMNR also reviewed several scientific articles on the subject of survival rations and discussed with the various service representatives the

type of information provided in survival briefings to military personnel. Copies of these materials are attached in Appendix III.

#### **Committee Recommendations**

1. The Committee on Military Nutrition Research concluded that in most survival situations conserving the need for water was of major importance. For this purpose adequate carbohydrate must be provided to prevent ketosis, protein intake should be limited and sodium should be restricted to a low level in order to help preserve water needs. In hot climates, additional sodium would be beneficial to help compensate for sweat loss, but only if adequate potable water is available.

2. The Committee has reviewed the scientific data base relative to the appropriate composition of survival rations and concluded that the criteria established by the early 1960's are still valid. (See, for example, report by Sargent and Johnson in Appendix III.) The criteria summarized in these earlier reports (Calloway, 1960; Sargent and Johnson, 1957) as well as the review of Davenport et al (1971) suggested a maximum of seven to eight percent of total calories as protein; a minimum of 100 grams of carbohydrate per day; and a minimum of one to two grams of sodium per day. Additional sodium should be available for use in hot environments, provided an adequate supply of potable water is available.

3. The current development effort that proposes the use of the series of cereal-type bars having approximately 5 percent calories from protein, 53 percent of calories from carbohydrate and 42 percent of calories from fat is considered appropriate for meeting the needs of all survival rations. No requirements for micronutrient fortification are considered necessary because of the short duration of use. However, inclusion of a bullion-type source of sodium is desirable provided this product is clearly labeled for use only when adequate water supply is available.

4. The Committee noted that discussion of reports of army personnel swapping survival ration components or discarding components having different amounts of carbohydrate and fat was of concern. The ration components must all be acceptable so selective consumption is not likely to occur. If only the high fat components are consumed and the high carbohydrate components are avoided, the potential for development of ketosis is enhanced with a resulting serious impact on water requirements and the ability to function both mentally and physically. In this regard, additional research in the area of palatability with the current cereal-type bars may be warranted. It would be important to determine that the ration

maintains its palatability when subjected to the extreme environmental conditions possibly encountered during extended storage.

5. The Committee on Military Nutrition Research recommends that the development agency and the user agencies engage in close coordination during the development of the new survival ration. The objective is to coordinate the development of labels, directions for use, and the instructional material given to personnel during survival training. Since one ration is envisioned for use in all environmental conditions, it is important that the packaging and recommended instructions for use be carefully coordinated. Instructions that clearly state the appropriate use of the ration components under varying environmental conditions should be included on the ration container. It is suggested that a statement be added to the label emphasizing that all components of the ration should be consumed and that swapping or discarding components could result in adverse health effects.

6. The Committee believes that it is important for potential users to be very familiar with all aspects of the survival ration and understand the physiological benefits, organoleptic characteristics, the appropriate use of components under different anticipated survival situations and the limitations in providing long-term nutritional support. The committee therefore suggests that a review of the instructional material used in survival training be conducted as a part of future tasks. Since only one survival ration module is envisioned for all operational conditions, it becomes more important that detailed instructions concerning its use be given in survival training. Training programs should include emphasis on the necessity for maintaining adequate fluid intake regardless of environmental conditions.

7. The Committee also believes that more information about past actual operational use of survival rations in emergency situations (i.e., Southeast Asia experience) would contribute to the development of a superior ration. Such data should include the extent of ration use, organoleptic attributes, the condition of individuals who used the rations versus the condition of individuals who did not use the rations during survival conditions. It would also be useful to learn why the rations were not used in a survival situation. An analysis of this nature may provide useful information which will be important to the design of the survival ration and instructions for use in the future.

Future research on survival rations should include examination of compositions that may be effective in reducing urinary urea, such as inclusion of purified amino acids and/or ketoacid or hydroxyacid analogues. In addition, recent advances in knowledge of the physiological effects of

certain electrolytes should be evaluated in the context of their application to survival rations.

The Committee on Military Nutrition Research is pleased to note the multi-disciplinary effort that has gone into the development of the proposed ration and urges additional dialogue concerning the directions for use and the instructional material given during survival training.

#### References

Calloway, D. H. 1960. Nutritional aspects of the all-purpose survival ration: A critical appraisal. U.S. Armed Forces Med. J. 11 (4):403-417.

Davenport, R.E., J.K. Spaide, and R.E. Hodges. 1971. An evaluation of various survival rations. Amer. J. Clin. Nut. 24:513-523.

Sargent, F. and R.E. Johnson. 1957. The physiological basis for various constituents in survival rations. Part IV. An integrative study of the All-purpose Survival Ration for temperate, cold, and hot weather. Wright Air Development Technical Report 53-484, Part 4. 18 pp.

## *Appendix I*

**Summary and Recommendations  
from the Brief Report: *The Long  
Life Ration Packet (LLRP)***

**The Long Life Ration Packet  
(LLRP)**

**A Brief Report Submitted by  
The Committee on Military Nutrition Research  
Food and Nutrition Board  
Institute of Medicine  
National Academy of Sciences**

**to**

**Major General Richard T. Travis  
Commanding General  
February 18, 1991**



## **The Long Life Ration Packet (LLRP)**

### **Introduction and Background**

The Committee on Military Nutrition Research (CMNR) (See committee roster in Appendix I) was asked to review and comment on the nutritional adequacy of the Long Life Ration Packet (LLRP) under development by the U.S. Army Research Institute of Environmental Medicine (USARIEM). At the June 28, 1990 CMNR meeting at Natick information concerning the development of LLRP was presented to the committee. Copies of the briefing material received by the Committee are included in Appendix II.

In summary, the U.S. Army Quartermaster Center and School (PROV)(QMC&S) identified a need for an extended life operational ration that will be the primary assault/patrol and Pre-Positioned War Reserve Stocks (PWRS) ration. This extended life ration would be used during the initial ten days of conflict. The extended life capability of this ration would resolve current deficiencies noted in the Army's ability to rotate existing PWRS rations in a timely and cost effective manner. The LLRP will draw components from existing military rations, for example, from the Food Packet, Long Range Patrol; the Food Packet, Assault (FPA) and the Ration, Cold Weather (RCW). A description of these rations is provided in Appendix IIc. The expected shelf life of the LLRP would be ten years and it would thus meet many of the PWRS requirements with minimum rotation and restocking. The LLRP would also become the go-to-war ration for consumption from days one to ten (D+1 to D+10). It would be issued at one or two a day and then the Meals Ready to Eat (MRE) would be phased in as rear support becomes established. The LLRP would be compatible in terms of calories and other nutritional factors with the MRE to allow development of menu mixes to achieve acceptable interchange of the two rations.

The LLRP product presented to the Committee on Military Nutrition Research was shown to have reasonable troop acceptance, was inexpensive (approximately \$4.40), and had a projected ten year shelf life. The LLRP is provided in several menu forms each containing a dehydrated entree, a cereal bar, a cookie component, a candy component, an instant

beverage and an accessory packet. It weighs less than one pound for an individual meal. The product under current development was projected to meet the specifications required and would thus reduce the logistical burden to the military of maintaining the PWRS as well as allowing reduced long term storage of the MRE's resulting in fresher, higher quality stocks of this ration.

#### **Committee Recommendations**

1. The Committee on Military Nutrition Research is of the opinion that the LLRP should be nutritionally equivalent, in terms of nutrient content on a calorie basis, to the MRE or to the Military Recommended Dietary Allowances (MRDA) for restricted rations. Further, the stability of the nutrients in the LLRP and its components over the anticipated shelf life (i.e., 10 years) should be established.

2. The Committee could not assess the nutrient adequacy of the five LLRP menus described to them. The Committee recommends that the nutrient profiles of these menus be determined and compared on a calorie basis, to the MRDA standards. An appropriate fortification strategy should be developed to address any observed discrepancies. The importance of providing at least 100 grams of carbohydrate in the ration is emphasized to help prevent ketosis when consuming a restricted level of calories. Consideration must be given to the ability of this ration to support soldiers' needs in a heavy work environment. The CMNR recommends careful evaluation of an optimum ratio of carbohydrate, fat and protein that includes previous findings from research at USARIEM on increased carbohydrate calories and performance under varied altitudes and climatic conditions.

3. The Committee on Military Nutrition Research (CMNR) particularly noted that one of the requirements for the Long-Life Ration Packet was a 10 year shelf-life. The desirability of a long storage life for the LLRP is obvious. Minimizing ration rotation and restocking is important from a logistical and financial point of view. However, it is imperative to demonstrate that this long shelf life (i.e., 10 years) can be achieved while maintaining the stated nutritional objectives of LLRP. The CMNR wishes to emphasize the importance of an adequate quality assurance program to be certain that the ration delivers not only an adequate level of acceptance

but most importantly, the level of nutrients specified at the time of use which may be as long as 10 years following manufacture. This is viewed as very important as it is likely that this ration will constitute the only source of nutrition in the early phases of a military operation and its use could be continued for periods of several days and though not planned, extend for several weeks.

The CMNR has on at least three occasions<sup>1</sup> emphasized the importance of an appropriate surveillance program to document that rations planned for long periods of storage adequately meet the nutritional criteria not only at the time of manufacture but through long term storage. Storage evaluations should include exposure to the environmental extremes that may occur prior to actual use in military feeding. Accomplishing this will require repeated nutrient analysis of specific lots of LLRP components over a 10+ year period. This will establish the rates of change for specific nutrients and any needed formulation changes.

An effective quality assurance program starts at the time of ration development and is continued through ration procurement and storage under actual field conditions. While laboratory accelerated storage tests are important, periodic evaluation based on analysis of nutrient composition and organoleptic characteristics over the planned shelf life is essential to assure that a nutritionally adequate and acceptable ration is available when actually put to use.

Generally, chemical analysis of foods provides an acceptable measure of nutritional quality. Such conclusions assume that the nutrients are biologically available. This is a reasonable conclusion, as a general rule. However, in formulating rations and components of rations for extremely long shelf life and to survive environmental extremes, new or different technologies may be applied which could alter bioavailability. For example, chocolate coatings used in such rations are likely to have high melting points

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<sup>1</sup>Please note the comments in the Annual Reports of the CMNR for the year September 30, 1982 to September 29, 1983 (Pages 7 and 8); for the period September 30, 1983 to September 30, 1985 (Page 15) and the Annual Report for the period August 1, 1985 to July 31, 1986 (Page 8 and Appendix D page 25). Excerpts from these reports are included in Appendix III.

and hence be less digestible than coatings of lower melting points. This could significantly reduce available calories. Similarly, encapsulation of vitamins could be used to minimize loss in storage. Some encapsulating systems may protect the vitamin but also reduce its bioavailability. Consequently the committee believes it is desirable to assure the bioavailability of nutrients through appropriately designed animal tests.

4. The CMNR recommends that current Quality Assurance programs for other long shelf-life rations be examined to ascertain their adequacy in providing assurance that ration quality including nutrient content is maintained to the time of actual use by military personnel in the field.

5. Instructions for rehydration of the entree should stress the use of potable water. The CMNR further suggests that instructions for use of the LLRP and other rations should be periodically reviewed for clarity and accuracy.

In conclusion, the Committee on Military Nutrition Research is pleased to provide these recommendations as part of its ongoing activities in assisting the Nutrition Division of USARIEM to assure the nutritional adequacy of combat rations.

*Appendix J*

**Summary and Recommendations  
from the Brief Report: *A Nutritional  
Assessment of U.S. Army Ranger  
Training Class 11/91***

**A Nutritional Assessment  
of  
U.S. Army Ranger Training  
Class 11/91**

**A Brief Report of  
The Committee on Military Nutrition Research  
Food and Nutrition Board  
Institute of Medicine  
National Academy of Sciences  
to  
Major General Richard T. Travis  
Commanding General  
U.S. Army Medical Research and Development Command  
March 23, 1992**

**Produced under grant number DAMD17-92-J-2003 between the National  
Academy of Sciences and the U.S. Army Medical Research and  
Development Command**

## INTRODUCTION AND BACKGROUND

At the specific request of the COL Eldon W. Askew, Ph.D., Chief, Military Nutrition Division, U.S. Army Research Institute of Environmental Medicine (USARIEM) the Committee on Military Nutrition Research (CMNR) met in Washington, D.C. on February 5-7, 1992. COL Askew is the Grant Officer Representative of the U.S. Army Medical Research and Development Command (USAMRDC) for Grant no. DAMD17-92-J-2003 to the National Academy of Sciences for support of the Food and Nutrition Board's (FNB) Committee on Military Nutrition Research. The purpose of this meeting was to assist the Army in reviewing and evaluating the results of a research project conducted during the training program for U.S. Army Ranger Class 11/91.

### Background Materials

Prior to assembling in Washington, the CMNR (the Committee) reviewed: 1) a background paper; 2) an information paper; 3) preliminary tables of results; and 4) a list of questions raised by the study. These background materials were provided by COL Askew. Copies of this information plus the meeting agenda, committee roster, lists of speakers and guests, and the data tables presented as slides or overheads during the meeting, are appended to this report.

### Committee on Military Nutrition Research Meeting, February 5-7, 1992

On February 5, 1992 the CMNR convened at the National Academy of Sciences, Washington, D.C. Due to the nature of the research project, the Committee invited five advisors to attend the meeting to augment their expertise in the areas of energy metabolism, vitamin/mineral nutrition, immunology, and protein metabolism. In addition, a guest scientist who has conducted extensive studies of the Norwegian Ranger Training Program participated in the presentations and subsequent discussion. During the meeting the CMNR viewed a videotape of the Ranger Training Program, and heard a presentation of the goals of Ranger Training, presentations of the research results of the study: A Nutritional Assessment of Ranger Training Class 11/91, a report of the preliminary results of a study conducted by the Walter Reed Army Research Institute (WRAIR) at the Ranger School, and general commentary by the five guest advisors. The nutritional

assessment study was conducted by the Military Nutrition Division, USARIEM, in response to a request from COL John J. Maher, III, Commander, Ranger Training Brigade. The CMNR was requested to review the results of the nutritional assessment study conducted by USARIEM and through their answers to the questions posed by COL Askew, make recommendations regarding the nutritional health and well being of Ranger trainees and future areas for research.

On February 6 and 7, 1992 the Committee and their guest advisors met in Executive Session and reviewed the research results in light of the goals and mission of the Ranger Training Program. The group discussed these materials at length jointly and then met in smaller groups to draft this report. After the Committee meeting, the Committee, their advisors, and staff worked together to review and revise subsequent drafts and components of this report. All CMNR members present at the meeting and their advisors have seen and approved the report. Subsequent to approval of the final draft by the Committee and their advisors, in accordance with National Research Council guidelines, this report was reviewed in confidence by a separate anonymous scientific review group. The Committee and advisors have reviewed the anonymous comments of this review panel and incorporated their suggestions where appropriate. Staff has then written a letter of response to the reviewers with the final report draft and obtained final approval of the report from the review panel. This report is thus a thoughtfully developed presentation that incorporates the scientific opinion of the CMNR, their advisors for this project, and the anonymous National Research Council reviewers.

#### **Report Organization**

Presented below is a listing of the questions posed to the Committee followed by a summary of the CMNR's recommendations. In the latter part of this report the Committee specifically address each of the questions posed by COL Askew and included with each answer is a general overview and specific recommendations. The report concludes with suggestions for areas where future research appears warranted. All materials used by the Committee in their deliberation process are included in the Appendices.

#### **QUESTIONS POSED TO THE COMMITTEE**

1. Is the change in the nutritional status of Ranger trainees of sufficient magnitude to compromise their health during Ranger training?



2. Are the changes in nutritional status noted transitory and not cause for undo medical concern, or are they severe enough to cause concern for the long-term physical health of the individual (post-Ranger Training)?
3. Are the immunological changes noted related to the plane of nutrition during Ranger Training or to other (eg. sleep deprivation) stressors?
4. Realizing that food restriction is an integral part of Ranger Training, can the nutritional status (risk) be improved significantly by relatively minor changes in the plane of nutrition?
5. Should Ranger trainees be furnished with multivitamin supplements?

#### **SUMMARY OF SPECIFIC RECOMMENDATIONS**

In answer to the questions posed above, the Committee deliberated and developed specific answers that are detailed in the sections below. Based on their deliberations a summary of the recommendations that arose from answers to the combined questions are as follows:

##### **During Ranger Training**

- establish a "food doctrine" to prevent excessive weight loss
- establish a maximum allowable body weight loss for Ranger Training consistent with Army guidelines
- review protocols for assuring the health of trainees during the entire training program
- consider modifications to apparel worn by Ranger trainees that will reduce dermal injuries and inflammation
- protocols need to be developed to document the occurrence, timing, severity, and etiology of clinical findings, such as overt infections, dermal injuries and inflammation, and problems related to climate, as well as prescriptions of all medication
- apply 1 of the 3 suggested modifications to the feeding program possible by immediately implementing the use of the Food Packet, Long Range Patrol (Improved) (LRP)
- develop a post-training refeeding and preventive health education presentation with and written materials for the guidance of training program participants

**Short term follow-up**

- expanded exit exam for all trainees
- physical exams at 3, 6, 9, and 12 months in the first year post-training that include physical, clinical and biochemical measurements
- during the first 6 months, careful attention to the residual capacities of the Rangers, especially personal motivation, history of infection and illness, weight gain and body composition, ventricular and diaphragmatic muscle function, hydration of lean tissue, and thermoregulatory capabilities

**Long term follow-up**

- expanded yearly physical exams if possible with a recorded history of major illnesses
- further prospective studies only if warranted
- conduct retrospective research study using existing data bases

**A General Comment**

There was an important question not posed to the CMNR. This question is:

What degree of stress through such stressors as food deprivation, sleep deprivation, extremes of environment and physical and mental performance tasks, under the watchful eyes of evaluators, is necessary to achieve the training objectives?

This question cannot be answered from the data presented and is one that is surely of concern to the Ranger Training Command. The data presented from the study are useful input to the decision process and can help answer questions about the impact of training on nutritional status, and short term medical and immune function concerns. Longer term evaluations can be achieved by both prospective and retrospective studies as suggested in the report. Obviously personal motivation of participants is an exceedingly important factor in completing the rigorous Ranger Training Program. Appropriate monitoring of individual trainees is needed to make certain that this high degree of motivation does not lead to excessive tolerance of conditions that need medical attention.

The Committee has no knowledge to what extent the attainment of training objectives is achieved. The CMNR encourages the Army to systematically evaluate all aspects of the Ranger Training Program and its components through follow up interviews conducted immediately after training and a number of years post-training. Such assessments, if not already in place, would provide direct information to the Training Program about the elements of the training experience that soldiers found were most beneficial to their later leadership abilities and performance in combat or during special operations.

#### **REVIEW AND DISCUSSION OF QUESTIONS**

In the following section the five questions posed to the Committee are specifically answered. After each answer the CMNR presents an overview of their reasoning and rationale as well as their recommendations as they relate to the question posed.

**Question 1: Is the change in the nutritional status of Ranger trainees of sufficient magnitude to compromise their health during Ranger Training?**

**Answer:** Yes. Based on a median body weight loss of 15.6%, documented infection rates that increased to 25.3% and 24.1% at the end of training (Phases III: Jungle and IV: Desert, respectively), and immune system markers, in the data as presented, there is indication that the health of Ranger trainees is at risk during the later phases of training. Trainee health may also be compromised for a period post-training.

#### **Discussion and Recommendations:**

The Committee notes that COL Maher should be complimented for his concern regarding the strenuous nature of the Ranger Training Program. The Committee also applauds the efforts of the USARIEM research group to study the issues involved in Ranger Training.

The Committee recognizes that Ranger Training is an important part of the military training needs of the Armed Forces. Further, that deprivation of food and sleep together with high levels of physical performance in extremes of environmental conditions are essential for the proper training outcome. Also it is recognized that such a program presents certain

inherent health risks that must be balanced against the benefits derived from this training, such as awareness of the impact of nutritional deprivation on physical performance, morale and judgement. The strenuous nature of the training necessitates careful medical monitoring of participants. The Committee therefore suggests that there be a review of protocols for medical monitoring to assure the health of trainees during the entire training program. Such a review should take into account the current knowledge about risk of infection, heat stress, hypothermia, and other serious health complications that might be anticipated during training.

The Committee recognizes that while there has been a long history of success with the Ranger Program without obvious harm to participants, however there has not been a critical review of the longer term health effects on trainees after they complete or leave their training. Therefore, it is recommended that a short term follow-up study be conducted with a number of graduates of the program to assess the relative level of health problems in Ranger graduates compared to other military personnel. This follow-up study should take into account the type of initial assignment and the environment to which the individuals have been assigned as well as other factors that may have an impact on recovery and health.

**Question 2:** Are the changes in nutritional status noted transitory and not a cause for undue medical concern, or are they severe enough to cause concern for the long term physical health of the individual after Ranger Training?

**Answer:** The Committee was impressed by the scope and careful research design of the studies performed by USARIEM during Ranger Training - despite extremely difficult conditions. In particular, the CMNR recognizes the thoroughness of the research approach as exemplified by the effort and careful planning involved in movement and recalibration of the dual energy x-ray absorptiometry equipment to the field sites. However, these studies are not sufficient to provide definitive answers to the question of whether the future health of the Ranger trainee is affected. The health of each trainee would need to be examined in both the short term (weeks to months) as well as the long term (years) following the completion of training. The Committee recommends that such studies be considered.

**Discussion and Recommendations:**

The short term considerations after such training involve the immediate ability of a Ranger to lead troops in combat and/or special operations. This individual may find himself under stressful conditions before there has been sufficient time or proper conditions to repair the losses which were incurred during the training conditions. Here it is important to consider not only the extreme loss of adipose tissue<sup>1</sup> and much smaller (but perhaps significant) loss of lean tissue, but the functional corollaries of such loss.

There is need for improved nutritional markers that examine the correlation between changes in body composition and loss of critical function. The loss of ability to function in a combat setting includes many things, from subtle loss of judgment to obvious weakness, fatigue, and loss of endurance. There is substantial evidence that loss of body protein stores is not confined to skeletal muscle alone, but is associated with a corresponding loss of ventricular, diaphragmatic, and intercostal muscles. The residual capacities of the Rangers at the end of training for both ventricular work and work of respiration needs to be examined. In addition, there is concern about the possible loss of specific protein and also the level of neurotransmitters derived from amino acids as related to brain function under such stressful conditions which may thus warrant further measurement.

In the short term it would also be important to examine the hydration of the lean tissue since it may vary more than predicted under severe field conditions and thus may influence the calculated changes in body composition. This could be approached by utilizing the data from the doubly labelled water to obtain total body water which could be compared with the dual energy x-ray absorptiometry (DEXA) data on body composition.

Finally from the short term perspective, much emphasis in the presentations was placed on the extremely high individual motivation that allowed many to finish (some to barely finish) the training course, and, that without this motivation, many of the successful candidates would not have completed the course. The Committee cautions that the aftereffects of such

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<sup>1</sup>There was a change from an average of 14.6% body fat (Range: 5.7 - 26.1%, n = 55) at the beginning of training to an average of 5.8% body fat (Range: 4.4 - 11.9%, n = 55) at the end of training (see Appendix IVe.).

sustained motivation and performance during Ranger Training may be evidenced in variable functional performance and motivation over the ensuing days and weeks post-training. This aspect needs consideration and possible inclusion in future studies.

The possible long term health effects of such an extreme loss of body fat are largely unknown and are an important concern. B-mode imaging ultrasound, magnetic resonance imaging (MRI), and bioelectrical impedance techniques might be combined with DEXA to obtain further information on the changes that have occurred in muscle and fat and the distribution of the body fat which is regained post-training.

At present, there is not adequate information about changes in weight or metabolism during the first year post training. To monitor longer term health we propose that standardized physical examinations should be performed quarterly during the first year after training and subsequently at the regular six month intervals for several years if results from the first 12 months indicate such a prospective approach is warranted.

In addition, a central question of the Ranger Training Program relates to the functional significance of certain nutritional markers such as weight loss. The loss of immunocompetence with an increased incidence of clinical infections may represent important evidence of functional loss as a result of combined nutritional, environmental, and psychologic stress. The impact on the immune system of the high intensity physical activity coupled with under-nutrition deserves further exploration. Similarly, the impact on the sympathetic/adrenal system should be more rigorously ascertained, at least on an acute basis as indicated by recent reviews and commentary in this area (Chrousos and Gold, 1992; Wellness Letter, March, 1992).

It remains to be demonstrated just what proportion of the decreased immunocompetence is specific to nutritional deprivation, however, it is also important to examine the problems associated with regulating body heat content in the light of nutritional deprivation. One of the speakers remarked: "Heat was the enemy early in the course and cold became the enemy toward the end of the course." This quotation referred to the variability in environmental temperature during the eight-week training period. For Ranger trainees, environmental temperatures may vary greatly depending on the Phase of training, hence training location in the desert, jungle, or mountains. In addition, the extremes of climate in these

environments seasonally change dramatically and therefore the successive Ranger Training classes may experience widely varying external climates.

This quote is thus equally applicable to the problem faced by individual soldiers in regulating internal body temperature. "Cold as the enemy" at the end of Ranger Training was to be expected, in part, as a result of intermittent hyperthermia during heavy exercise and hypothermia secondary to cold exposure. However it has been shown that the thermogenic response to a mild cold challenge is progressively lost with weight loss in hospitalized patients. Furthermore, this thermoregulatory deficit with weight loss can be restored with nothing more than partial regain of body weight. Perhaps this functional loss of thermoregulation with progressive weight loss causes the vulnerability to hypothermia seen in the later weeks of Ranger Training.

The measurement of energy expenditure using doubly labelled water offers obvious advantages for field studies such as Ranger Training. However, certain assumptions are required for the use of this method, that usually include a stable food intake and hence a stable mid-range respiratory quotient (RQ) throughout the period of the study. Since this is undoubtedly not possible, special attention needs to be given to the need for periodic measurements of gas exchange or other approaches to the variations which might be expected in the RQ.

It would also be important to collect urine samples and estimate dietary protein intake for periods of two to three days during selected parts of the training. A knowledge of nitrogen excretion, even if only of urinary nitrogen, would be important in interpreting the weight loss and fat loss in each phase of training.

One particular aspect deserves comment. The observed small proportion of lean tissue loss versus the high proportion of fat loss, gave rise to repeated comments during the presentations that the results of the training were primarily those of an energy or a calorie deficit. This may be true only in an overall sense. For example, if one only uses data on the lean tissue present at the beginning and end of the training and thus calculates an average daily nitrogen loss, this average loss over time is seen to be relatively modest. However, the nitrogen excretion during certain selected periods of training may be much higher than the daily average. If this is true, brief periods of serious nitrogen loss might cripple fast-turnover proteins such as certain of the acute phase proteins and perhaps contribute to the

growing vulnerability to infection reported in the second half of the training course. This supposition is of course, speculative but potentially relevant.

**Question 3: Are the immunological changes noted related to the plane of nutrition during Ranger Training or to other (eg. sleep deprivation) stressors?**

**Answer:** It is impossible to answer this question with the data now available - even though these data are extremely valuable and truly unique. Data emerging from the studies produced by USARIEM, by WRAIR and by Dr. Per Christian Opstad of Norway in the more rigorous but shorter deprivation studies on Rangers in that country, are not always consistent. Between-study differences may be due to differences in length of studies, in timing of sampling, degree of caloric restriction and sleep deprivation, and ambient temperature. The fact that climatic and other stresses involved during data gathering were not consistent must also be considered. Further, the methodologies of conducting certain tests, and of the analysis, presentation, and interpretation of data gathered by these three groups, were not always uniform.

Nevertheless, an overall consensus of the data certainly indicates the occurrence of numerous immunological compromises in the Ranger trainees. These involved T-cell and B-cell dysfunctions, and also those of phagocytic cells.

#### **Discussion and Recommendations:**

The T-cell deficits included variable reductions of delayed dermal hypersensitivity reactions and disturbances of in-vitro T-cell responses to mitogens. The B-cell deficits (undoubtedly in combination with altered T-cell and antigen-presenting cell functions) resulted in poor antibody responses in both primary and secondary exposure to vaccine antigens. Changes were noted in neutrophil performance of oxidative functions. Changes were noted in the numbers of the various circulating white blood cells. Cytokine measurements in both serum and cell culture fluids are still quite novel, but they too demonstrated changes that are undoubtedly meaningful, but presently, these cytokine data are difficult to interdigitate with other data for meaningful interpretation.



In regard to the immunologic profile examined however, there was no assessment of natural killer (NK) cell activity, nor assessment of the phenotype of important sub-populations of lymphocytes such as CD4, CD8, or CD3/CD56, which might be expected to be affected by the training. These assessments would have given considerably more insight into the effects on the immune system. NK activity has been shown in several studies to be particularly affected by stress (for example, Levy et al., 1991 a,b).

There were technical aspects of the processing of the samples that might have had an impact on the results. After collection, blood specimens were held at ambient temperatures for over 24 hours. It is quite likely that the measurements obtained were affected by such storage prior to separation of cells and plasma. Since environmental conditions varied substantially during training, the test results may have been affected by shifts in temperature and other parameters for which there was no apparent control. In addition, plasma cytokine assays are often difficult to control for quality under optimal conditions. The results of this project should be interpreted with caution due to the sample processing issues mentioned above. Further studies utilizing better control procedures for collection, separation and storage of samples would seem important.

It should be noted that the study conducted on Ranger Training Class 11/91 (Appendix IVh.) showed no significant reduction of delayed cutaneous hypersensitivity reactions, whereas the WRAIR study of Ranger Training Class 12/91 (Appendix IVk.) pointed to a depression in such reactivity. It is difficult to compare the results directly since there was less specific data provided at this time from the WRAIR project. After the scientists involved have had the opportunity to more fully analyze the data from both projects (for example, see below), joint discussion of the results would be informative.

It is also difficult to adequately assess the changes that appear to have occurred with regard to the in vitro testing. Analyses performed were entirely based on pooling data for each time point, rather than using each individual as his own control and utilizing alternative statistical analyses. It is recognized that the presentation to the CMNR was based on preliminary data analysis by the scientific teams. As the analysis of this data progresses with the addition of standard deviations and more extensive statistical procedures, the results will be more readily interpreted.

Over 50 percent of the Rangers developed infections requiring antibiotic treatment during the USARIEM study. These infections primarily involved the lower extremity, and included cellulitis of the knees, legs, and feet. In view of the significant number of infections of the lower extremities, special attention should be directed to reducing stress on the legs and feet. Examination of procedures for proper design and fitting of the Ranger boot is suggested. A numbing sensation in the toes has long been a recognized problem among soldiers. Limited more specific data on digitalgia paresthetica of the toes (numbing of the toes) from an Israeli Defense Forces study indicated that this condition was a neuropraxia related to soldiers adaptation to marching with heavy packs (see Appendix IVm.). The CMNR thus suggests that Ranger boot fitting be done in such a manner that gait accommodation to carrying heavy loads is considered. In addition, since many of the abrasions that may subsequently lead to infection apparently occur in the knee area, special padding of the uniform such as knee pads that can be inserted in the uniform may be appropriate. Knee pads that are strapped on over the pant legs are often uncomfortable, more cumbersome, and hence less likely to be used by the soldier.

In addition, respiratory tract infections were prevalent; the *S.pneumonia* carrier rate was unusually high in this study despite bicillin prophylaxis. The several respiratory infections were not adequately characterized in the information provided to the Committee with regard to etiology. It is quite possible that a substantial proportion of these were viral in nature, particularly since other clinical studies have indicated that difficulties in handling stress may be associated with increased frequency and morbidity from viral respiratory infections, concomitant with depressed NK activity (Levy et al., 1991 a,b). Gastro-intestinal infections have also caused problems in other Ranger Training classes. However, it is currently impossible to identify the exact cause of these clearly identified impairments in immunological functions and host resistance, i.e. to assign blame to the nutritional losses versus the stress (or any one of the many stresses being experienced).

Training-imposed dietary restrictions certainly contributed to losses of body weight and nutrient stores. Arduous physical activity certainly contributed to increased metabolic demands and high rates of nutrient expenditures. The complex and interacting physical and emotional stresses certainly altered the hormonal milieu of the body in these trainees, with multiple secondary metabolic consequences. And of especially great

importance, the extreme physical exertion, the multiple minor injuries and inflammatory responses, and the intercurrent infections could each (alone or in combination) have triggered acute-phase reactions and cytokine releases.

Acute phase responses, if triggered by the endogenous release of the cytokines IL-1, IL-6, and TNF [cachectin], could result in hypermetabolism, accelerated catabolism of somatic body proteins, hormonal changes, extensive metabolic changes in hepatic cells, and a wide variety of nutrient losses. The type of cachexia produced by the acute phase response could lead to immunological dysfunctions. Cytokine initiated cachexia is hypothesized to be a more important cause of nutritionally-induced immune system dysfunctions than simple uncomplicated starvation in adults. The available USARIEM data suggest (but do not prove) that acute phase responses were occurring during the Fort Benning Phase of the Ranger Training Program.

Occurrence of acute phase responses early in the Fort Benning Phase of the USARIEM study is suggested by early changes in iron-related data. These include the fall in serum iron values, the increase in unsaturation in serum iron binding capacity, and the increase in serum ferritin values. These changes are all indicative of an IL-1 induced movement of iron from plasma for temporary sequestration in tissue storage sites. An increase in BUN also suggests an increased protein-catabolic response (which would not be observed in uncomplicated starvation), as does the previously discussed hormonal data.

Additional data to confirm the occurrence (or absence) of an acute phase reaction during Ranger Training would be desirable in future studies. Such data should be gathered with appropriate timing to detect possible abrupt declines in plasma zinc values (as well as those of iron), abrupt declines in plasma free amino acid (especially glutamine) values, a slower increase in serum copper values, and an increase in plasma concentrations of the acute-phase reacting plasma proteins, such as haptoglobin, C-reactive protein, orosomucoid, and ceruloplasmin, as examples.

Committee discussions emphasized the need for measurements of circulating free glutamine concentrations. This would provide an important index of the relative depletion of this specific amino acid as a consequence

of a catabolic response involving the breakdown of body protein, especially muscle protein.

Additionally, and of special importance to the immunological questions at hand, is the growing body of reports that adequate glutamine availability is essential for normal immune system function. Current data suggests that glutamine repletion reduces microbial colonization and the incidence of infection in immunocompromized catabolic patients.

However, a combination of cytokine-related catabolic stress coupled with diet-induced protein-energy malnutrition consistently leads to a synergistic combination in which immune system functions and other host defense measures are severely compromised, and secondary infections are common.

The magnitude of food deprivation in the trainees is well documented by excellent measurements of body composition and anthropometric findings as well as by losses of body weight. The extreme hunger experienced by the trainees constituted an important emotional stress -- severe enough to cause some of them to violate honor code requirements. However, available immunological data and increased infection rates cannot, at this time, be ascribed solely to nutritional deprivation. Historical evidence shows that severe starvation alone (in the absence of other stresses or catabolic illnesses) may not be rapidly detrimental to immune functions, and may not lead to an increased susceptibility to infectious illnesses.

Multiple concomitant stresses (purposely imposed on the trainees, and probably necessary for the military success of the program) include food and sleep deprivation, arduous, prolonged, and at times, dangerous training requirements, and the self-imposed drive to succeed. These stresses cannot be differentiated by any currently known hormonal or psychological profile. The presence of such stresses is reflected by the newly available hormonal data, including those defining changes in serum cortisol, testosterone, and insulin-like growth factor I values. Further, it is impossible to determine if these stress-compatible hormonal changes were due solely to some single observed stress (i.e., sleep deprivation, hunger, the other physical and emotional variables, alone or in combination), or if they were concomitant aspects of an acute phase response, or even of protein-calorie malnutrition. More consideration should thus be placed on the likely influence of psychological stress and the perception of all aspects of the stress by the

trainees. Other studies of the effects of stress on the immune system have indicated the importance of the perception of stress and the ability of the individual to handle stressful situations. This might be quite heterogeneous among the trainees. Personality and psychological assessments of stress and its effects on psychometric parameters should thus be seriously considered for future studies.

In regard to attempts to sort out the effects of various variables on the immunologic parameters, it is worth mentioning that the Office of Naval Research has recently been performing detailed studies of the psychological effects of regular basic training of naval recruits on the immune system. This type of training, although quite less rigorous and physically stressful, has been associated with multiple changes in immunologic function. Insight into such comparative data seems pertinent to the studies of the Rangers. This is also related to plasma beta endorphin which has been shown to correlate with stress-related alterations in NK activity.

Further research during Ranger Training should, ideally, include prospective, controlled studies which will identify the occurrence, duration, and severity of acute phase reactions, should they occur. Data should include several biological indicators of the acute phase reactions, as well as measurements of key cytokines and their receptors. Investigative priorities should be clearly established, however, since all studies and additional data mentioned in this section cannot be accomplished and still meet the goals of Ranger Training.

Immunological studies, including responses to primary and secondary immunization, should be repeated in additional trainee groups. This will broaden the immunologic data base, and help to certify its consistency, since different Ranger classes experience different climatic and other stresses during their training cycle.

A standardized protocol involving adequate medical observations is needed to document the occurrence, timing, severity, and etiology of clinically evident infections, and to correlate with immunologic and nutritional findings.

The data on vitamin and mineral nutrition already obtained is excellent and does not need to be repeated. Information on possible changes in Vitamin E, zinc, copper, and selenium must still be gathered.

Other nutritional data, including effects of the training and associated stresses on protein and amino acid (including glutamine) metabolism, would be helpful. This would be even more important if future studies permitted increased feedings during brief periods between training phases. Naturally, all these data should include adequate pre- and post-training controls.

Previous prophylactic antibiotic use has been authorized. Additional preventive measures should be considered to avoid inflammatory skin lesions, such as padding sewn into uniforms to protect knees, as previously described, and also for pressure point areas of packs and equipment. Drug prophylaxis should be considered to block prostaglandin-related components of the acute phase reaction.

Ranger Training does introduce many biologically important variables concomitantly, or in rapid succession. We are therefore dealing with a multifactorial problem, one in which the individual components may never be fully differentiated. While additional research data will be most useful, present steps to avoid or minimize the immunology-related medical problems encountered during Ranger Training include:

- nutritional augmentation compatible with training requirements (these may include increased intake of calories and/or protein);
- improvements in military uniforms to reduce dermal injuries and inflammation, in particular, better fitting boots to reduce toe numbness and risk of foot infection and possibly adding foam insert pads to the knee area of trousers used during training;
- better surveillance of infection incidence;
- judicious use of prophylactic measures to prevent infections; and
- possible use of prophylactic agents (i.e., ibuprofen, aspirin) in doses sufficient to minimize prostaglandin-related components of the acute phase reaction without masking symptoms of a developing infection.

Question 4: Realizing that food restriction is an integral part of Ranger Training, can the nutritional status (risk) be improved significantly by relatively minor changes in the plane of nutrition?

Answer: Yes. The charge to the Committee is to recommend alterations in nutrition that might result in a reduction in attrition and decrease nutritional risk. The Committee recommends that this be accomplished by establishing a "food doctrine".

**Discussion and Recommendations:**

Critical to answering this question are the two major principles of Ranger Training:

- Deprive the soldier of sleep and food while pushing him to the maximum of his endurance. The purpose of this exercise is to show future leaders at what point they reach their limit of effective function, and conversely, at what point their men would predictably reach their limit of effective function.
- Creating and maintaining periods of hunger is of critical importance to achieving the desired level of multi-faceted stress on the soldier.

An important aspect of the data presented by the Walter Reed Army Institute of Research (WRAIR) study (Appendix IVk.) was that soldiers on field training exercises (FTX) who were given two Meals-Ready to Eat (MREs) per day did not experience the cognitive dysfunction characteristic of the USARIEM study. This suggests the possibility that one of the two major principles of Ranger Training would not be realized with sufficient feeding. Thus the CMNR recommends that, instead of increasing total food intake, a more specific "food doctrine" be adopted. Just as the Army has a "water doctrine", a "food doctrine" can be viewed as important for optimal performance. Such a food doctrine could be incorporated into the Ranger School Operations. This would include the provision and consumption of adequate energy intake for optimal performance at times when food is available. It would be put into practice by providing guidelines for acceptable body weight loss during non-field operations and include maximizing food intake whenever possible during field operations. There is no set allowable body weight loss for prolonged field exercise according to U.S. Army policy, however 3% body weight loss is often used as a guideline. For Ranger Training, the Committee recommends that the Army establish a specific target for maximum percent body weight loss. This target would be based on the results of the present study and future research on the effects of the degree of weight loss on physical and cognitive performance and immunocompetence. The CMNR suggests a preliminary estimate of this target might be in the range of 10-12% body weight loss overall.

In addition to the implementation of a food doctrine, the Committee recommends review of the following three potential scenarios for altering

the current feeding status of soldiers undergoing Ranger Training. It is expected that these approaches would result in better nutrition and reduction in attrition rate:

- Match intake and output. Increase food intake to match energy expenditure during the non-FTX phases of training (part of the "food doctrine"). Continue to feed troops one MRE during the FTX training; this is likely to produce the desirable degree of deprivation during the later phases of training. It is possible that approach may not provide the appropriate deprivation early in the Fort Benning phase.
- Short bursts of deprivation. If greater deprivation is desired, it would be preferable to provide the deprivation in isolated periods of time, followed by periods of greater intake after periods of FTX training (part of the "food doctrine"). Such a scenario should result in less suppression of the immune function. It would be accomplished by further reduction of Intake during FTX, perhaps by altering one day of starvation followed by a day of feeding one MRE, for a total period that would last only about 7-8 days. Dr. Opstad has demonstrated that Norwegian Rangers can develop cognitive dysfunction within five days if they are almost completely deprived of food and sleep. The excess feeding following the FTX period would be of special importance to restore immune function and body weight more rapidly.
- Slightly increase intake yet still have deficit. Increase food intake during FTX training either by a moderate increase of 200-300 kcal/day such as by using the new Food Packet, Long Range Patrol (Improved) (LRP)<sup>2</sup> that provides a minimum of 50 grams protein and 1500 kcal or by providing two MREs per day. This level of feeding apparently was implemented during the study conducted by WRAIR that, based on preliminary data presented, indicated a decreased attrition rate compared with previous classes.

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<sup>2</sup> The Food Packet, Long Range Patrol (Improved) (LRP) is the new name for the USARIEM research and development product: the Long Life Ration Packet (LLRP) that was reviewed by the Committee on Military Nutrition Research in 1991 (Publication IOM-91-03, Institute of Medicine, National Academy of Sciences). Information on the menu components and estimated nutrient content are included in Appendix IVI.



Regardless of which alteration might be selected, given the levels of depletion in body weight and immune function in the USARIEM study, the CMNR is concerned about the health status of the individual soldier after completion of Ranger Training. Additional steps must be taken to ensure that the soldier is aware of the types of foods and weight gain that should follow the period of deprivation upon leaving training. It is the understanding of the Committee that the soldier is returned to his unit, which may actually, depending on timing, be in a deployment mode. Thus the opportunity for the soldier to regain lost body weight and immune function may be compromised if the following tour of duty is in an arena in which reduced rations and increased energy expenditure will predominate. Thus it is recommended that the Ranger Training Program include information on specific methods to regain body weight, lean body mass, and health status following completion of the training. Such nutrition education would include information on components in the various types of military rations and which components are critical to achieving the objectives of regaining body weight and health as quickly as possible.

**Question 5:** Should Ranger trainees be furnished with multivitamin supplements?

**Answer:** No, based on current data, significant benefits from the use of vitamin and mineral supplements would not be expected. However, future research may suggest the need for more specific supplementation and routine assessment of the vitamin/mineral status of trainees pre- and post-training through scheduled health exams should be considered.

#### **Discussion and Recommendations:**

The Committee recognizes the importance of essential vitamins and minerals in maintaining good nutritional status. The Military Recommended Dietary Allowances (MRDAs) assure that military rations contain the recommended quantities of these micronutrients in the foods consumed by the soldier. Based on this, personnel entering the Ranger Training Program are in good nutritional status. During the non-FTX periods the participants receive adequate food resulting in adequate intake of the micronutrients. When in the FTX phase of the training, participants receive one MRE furnishing 1300 kcal and at least 1/3 of the MRDA for micronutrients. During this time energy expenditure is dramatically increased.

Analysis of indicators for vitamin and iron status provides no evidence of any impairment of any biochemical indicators of nutritional status for these nutrients. This is not surprising because the subjects entered the program with adequate reserves. One would not expect deficiencies to occur in the short time of one week.

A transitory decline of serum iron concentrations after the baseline period was considered a stress response. This was further discussed in the earlier section on immune function. It is considered a result, not a cause of the acute phase reaction.

While zinc analysis was not reported for the participants, the central role of this element in immune functions is well recognized. During discussions it was reported that a preliminary analysis of four subjects did not indicate a decline in zinc status at the end of the training. We would not expect that zinc status would decline significantly during one week of food restriction because of compensatory increases of zinc absorption during reduced intakes and because participants were consuming at least 1/3 of the MRDA even during food restriction, however more data are needed to confirm this hypothesis.

Several other trace elements (i.e. copper, selenium) are also known to participate in immune reactions. The status of those elements was not measured. Marked deficiencies would not be expected to develop in the short period of time of reduced intake, however these could be measure instead of vitamins in subsequent studies.

#### AREAS FOR FUTURE RESEARCH

The USARIEM study provided much valuable data but also raised a number of important questions where more research is needed. Among questions raised are the following:

- 1) What are the relative effects of food deprivation and sleep deprivation on compromised immune function and inability to complete the course?

2) Are there any short term consequences (< 12 months) of Ranger Training on health status, body composition, and physical performance of Ranger trainees?

3) Are there any long term consequences (> 12 months up to 25 years) of Ranger Training on health status and body composition of Ranger trainees?

#### **Intervention Study**

To answer the first question, ideally, a 2-way factorial design in a single training class would be run. Treatment groups would be 1) adequate sleep, adequate food; 2) adequate sleep, food deprived; 3) sleep deprived, adequate food; and 4) sleep deprived, food deprived. Main effects (sleep, food) and interactions would be statistically evaluated with a 2-way Analysis of Variance (ANOVA).

However, the opinion of the CMNR is that it would not be feasible to conduct such a study in a training environment without compromising the training mission. We instead believe that the food issue should be investigated first, as described below. It is possible that at a subsequent time it may be desirable to examine the issue of the effects of sleep deprivation stress on immune function and success rate.

In a future class at Fort Benning volunteers could be randomly assigned to two groups: 1) less food; and 2) more food. The group given less food would follow the food protocol of the just completed Ranger study. The group provided more food would be allowed full access to food during the short periods between the field exercises and in the initial phase at Fort Benning. In the field exercises these trainees would be provided with two rather than one MRE per day. The data collected in this study would be essentially the same as that collected in the just completed Ranger study. Less emphasis could be placed on indicators of vitamin status and more on indication of immune function, selected minerals, hormonal status, protein metabolism, and body composition as indicated in the earlier sections of this report (see questions 2 and 3 above), as well as follow-up studies of Ranger trainees who were and were not successful in completing the course.

The CMNR recognizes that important logistical and morale issues are raised by differential treatment of trainees. If it is not possible to carry out a study as described above, we suggest that the study just completed be repeated at the same time of year, but that more food is supplied as described above. This design is much weaker and the results will be much less conclusive because the sequence of field exercises would be different, the weather and other environmental factors would be uncontrolled, as would be the variable presence of infectious disease. It is possible that some of the questions posed by Ranger Training may be addressed through carefully designed studies in more controlled experimental conditions using the environmental chambers at USARIEM.

It is suggested that any future evaluation projects include a systematic collection of data on mental performance. The addition of structured interviews in which probing questions are asked to further assess cognitive performance, would provide useful information. This could be done within the current training protocols. Comparison could be made with soldiers not undergoing sleep and food deprivation, but assigned to the same tasks.

#### **Short Term Follow-up**

From the results of the USARIEM study it seemed clear that graduates of Ranger Training were in a depleted nutritional and health status. The Committee believes it is important to follow-up the graduates in the first year immediately following graduation. At three, six, nine, and twelve months following completion of the course, a complete physical examination should be given, including clinical and biochemical measurements. The blood work should include assessment of immune function and hormonal status. Body composition and physical performance should also be assessed.

#### **Long-Term Follow-up**

If analysis of data collected from short term studies of Ranger Training classes indicate a need for further follow-up, consideration should be given to a longer term study of several years duration.

#### **Retrospective Study**

To address long term effects of Ranger Training in a cost effective manner, it would also be desirable to carry out an epidemiological

retrospective study in which all graduates of Ranger Training for the last 25 years are compared with matched controls who did not participate in Ranger Training. The needed data could be obtained from the medical records and other military data bases that are already in use for retrospective studies of this nature. The questions to be asked would be how the groups compared in mortality, morbidity, body composition, physical performance, and overall health status. The control group would need to be carefully matched for as many variables as possible other than undergoing Ranger Training. This study could potentially identify the presence of any major, long-term health risk factors associated with Ranger Training.

#### **CONCLUSION**

In conclusion the CMNR and their advisors found the questions raised by the Ranger nutritional assessment project to be of great importance. Further studies offer both improved conduct of Ranger Training and may also be of more general clinical importance for the care of injured and critically ill patients. The Committee on Military Nutrition Research is pleased to provide these recommendations as part of its ongoing activities in assisting the Military Nutrition Division of USARIEM.

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